Executed Design (1803) THE EXCHANGE, PETROGRAD ARCHITECT: THOMAS DE THOMON

Russian Art of the Petersburg Period*

BY R. BOKER (HONORARY CORRESPONDING MEMBER)

IN March 1922 an article by Mr. W. Henry Ward, M.A., entitled "Russian Architecture," brought to the notice of the readers of the JOURNAL of the R.I.B.A. the first volume of *L'Art Russe*, by M. Louis Réau, which had just been published by Henri Laurens, Paris. This volume dealt with the history of Russian art from the earliest times to the accession of Peter the Great. It has now been supplemented by a second volume, which brings the account up to the present day. Together they form a very complete record of the subject.

Anyone in Western Europe who attempts to write about Russian art at the present time, when intellectual relations between Soviet Russia and the civilised world are practically non-existent, labours under considerable difficulties. There is no doubt that M. Réau's volumes would have been far better illustrated if he had been able to obtain from Russia photographs and drawings of the works of art he describes. As it is, he has had to be content with borrowing most of his illustrations from such Russian works as he could find in Paris. From an architect's point of view, the complete absence of plans is much to be regretted.

Nevertheless, M. Réau has produced a valuable work which affords very interesting reading. His first-hand knowledge of Russia and of the most recent Russian literature on national art and archæology has enabled him to present Russian art in a far truer light than that in which it often appears in foreign (*i.e.*, non-Russian) works.

He treats its history in close connection with that of the *milieu* in which it developed. Thus he rightly emphasises the fact that the change wrought by Peter was by no means so sudden and unexpected as is often supposed. Russia had never ceased to be in contact with the West, and the gradual conversion of the ruling class to western ideas is the salient characteristic of Russian history for half a century before the advent of the great reformer. The desperate efforts of the reactionary party, which clung tenaciously to Byzantine and national traditions, were powerless to stem the ever-rising tide of occidentalism. Leading Russians grew more and more conscious of their brotherhood with the western nations. The reign of the Tsar Alexis, the father of Peter the Great, was a period of transition. The policy of this prudent and gentle ruler to a certain extent prepared the ground for the drastic reforms afterwards carried out by his impetuous and despotic son.

The year 1703 witnessed the foundation of St. Petersburg, now called Petrograd, and thenceforth the history of Russian art is practically a history of art in that capital.

If Russian art in general is, so to speak, a comparatively recent discovery, more especially is this true with regard to the art of the "Petersburg period." An intelligent interest in it has only arisen in our own day. The men who, in the middle of the last century, placed the study of Russian archæology and art-history on a scientific basis were deeply imbued with the Slavophil tendencies of their time, and consequently hostile to the western ideas of which Peter the Great's capital was the embodiment. The only epoch which they deemed worthy of consideration was the pre-Petrovian. With the advent of Peter, the history of Russian art, according to them, stopped, and all that subsequently took place was nothing but a regrettable error. The time when it was customary to talk like this is still remembered by Russians who have not yet reached old age. Despite the fact that the beauties of the "northern Palmyra" were

* *L'Art Russe de Pierre le Grand à nos jours*. By Louis Réau, formerly Director of the Institut Français at Petrograd. Paris, 1922. [H. Laurens].

TAURIDE PALACE, PETROGRAD (1783-1788) ARCHITECT: STAROV
(Presented by the Empress Catherine II to her favourite, Prince Potemkin " of the Tauride," on the conquest of the Crimea. From 1905 to 1917 the home of the Duma)

ARKHANGELSKOE, NEAR MOSCOW
Typical country residence of a Russian nobleman of the end of the eighteenth century

sung about a century ago by the poet Pushkin, in lines which every educated Russian knows by heart, the eyes of most Petersburgers were not opened to them till about 1900. On the eve of the bi-centenary of the foundation of the city, a newly created art journal, the *Mir Iskusstva*, devoted a special issue to St. Petersburg, which roused more than a passing interest, marking as it did the commencement of an important artistic movement. Three very successful retrospective art exhibitions helped to destroy the prejudices against St. Petersburg. The one devoted to architecture led to the inauguration of a " Museum of Old Petersburg," which, recently removed to a wing of one of the former imperial palaces, was originally housed in the private residence of Count Paul Suzor, Hon. Corr. Mem. R.I.B.A., now deceased, but doubtless still remembered by some of his foreign colleagues on account of the active part he used to play as Russian delegate at International Congresses.

The art of St. Petersburg was, of course, originally imported from the West. Excellent in their way as were the architects of Moscow, they were obviously incapable of carrying out Peter's designs. He therefore employed foreigners. During his journeys abroad, and at other times through his agents in foreign countries, he spared no exertions to induce artists and skilled artisans of all nationalities to come to St. Petersburg. The main advantage of the situation of the new capital, outweighing in his opinion all other considerations, was that it facilitated intercourse with the West. The first to arrive were the Dutch, for it was to Holland, the foreign country which he knew best, that Peter naturally first turned for assistance. Traces of Dutch influence can still be detected in the oldest buildings of St. Petersburg and of the Emperor's favourite summer residence—Peterhof. The Dutch were soon superseded, however, by Italians, Germans, and Frenchmen. Peter himself invited to Russia the distinguished French architect Leblond, and the latter brought in his train a large number of artists and craftsmen. From that moment it is, on the whole, French influence which predominates. M. Rêau even declares that Paris played as important a part in the formation of modern Russian art as Byzantium did in shaping the art of mediæval Russia. Possibly his patriotism prompts him to exaggerate a little. At all events, the importance of the work done by architects of Italian origin must not be under-estimated. The influence of Germany is less apparent. It is true that Andreas Schlüter, the celebrated Berlin architect and sculptor, spent the end of his life in Petersburg, but the authenticity of the works attributed to him there is doubtful. Moreover, as Baron N. Wrangel, a talented young historian of art, whose premature death during the war is much to be regretted, remarks in an essay entitled " Foreigners in Russia " (published in 1911 in the art journal *Staryé Gody*), there has always been a pronounced antagonism between Teutonic culture and the Slav character ; this fact prevented German influence on Russian art from ever being more than superficial. British influence is brilliantly represented in architecture by a Scotchman, Charles Cameron, one of the favourite architects of Catherine II, while some of the Russian eighteenth-century portraits are reminiscent of Reynolds and Raeburn, though the influence in this case is, of course, indirect.

In conjunction with the forcible occidentalisation of the upper classes, the influx of foreign artists was bound to lead to a schism between the art of the people and that of a small minority educated after the European fashion of the time. Until then, Russian art had been one. The architects who reared the churches of St. Basil the Blessed, at Moscow, and of Kolomenskoe and Fili, spoke a language intelligible to all Russians. The icon painters of Novgorod were sure of being understood not only throughout Russia, but in the whole of the Orthodox Slav world. Peter's reforms put an end to this homogeneity. The dualism which they produced in Russian civilisation, and which some people hold partly responsible for the catastrophe which has overwhelmed Russia, had its counterpart in the history of Russian art. Henceforth there was to be one art for the Court, the aristocracy and the educated class, another for the *plebs*. The former flourished chiefly in the capital, while the latter was condemned to an obscure existence in remote villages. The eighteenth century knew no middle class to serve as a link between masters and serfs ; the *bourgeoisie* only grew up in the nineteenth century.

The new, imported art had a more secular character than the old, indigenous art. Civil architecture, of which old Russia has left us so few examples, most of the buildings, including palaces, having been built of wood, acquired great importance. Though churches, even monasteries, continued to be built, the most characteristic structures of the new age are palaces, private mansions, theatres, and public and civic edifices of all kinds.

Painting, completely detaching itself from iconography, which gradually degenerated into a monastic craft, proceeded to treat every variety of subject, beginning with Græco-Roman mythology.

As for Russian sculpture, it was practically only born under the new *régime*, for the ban on that art, pronounced by the Eastern Church in the days of iconoclasm, had hindered its development in old Russia no less than the difficulty of obtaining suitable stone.

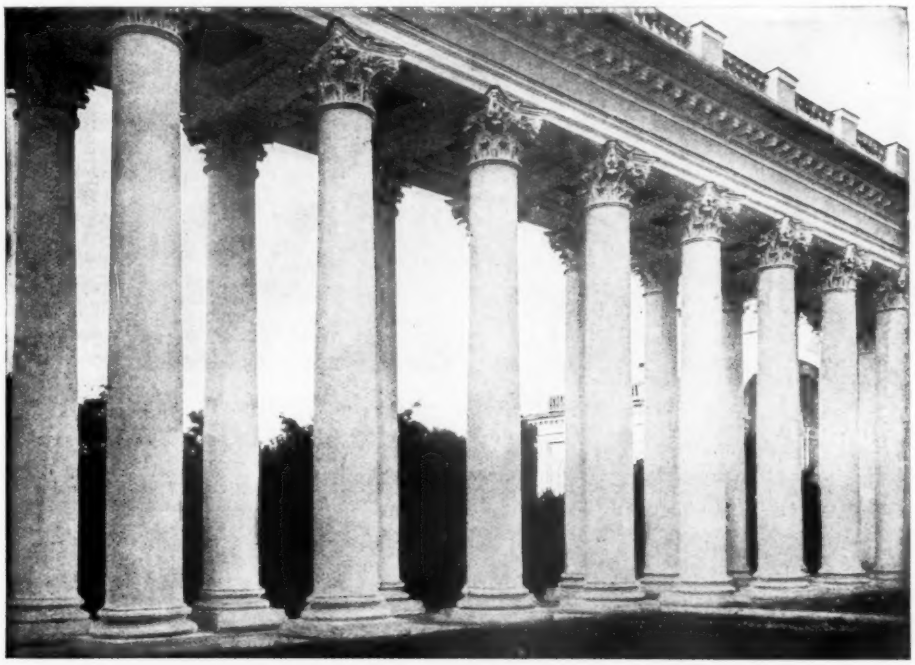
The eighteenth century also introduced important new decorative industries, such as the manufacture of tapestry and of art porcelain.

Initiated by Peter the Great, the work of building and embellishing the new capital was continued with no less ardour by his successors, notably by his daughter, the splendour-loving Empress Elizabeth, by Catherine II,

THE ACADEMY OF FINE ARTS, PETROGRAD (1765–1772). ARCHITECT : VALLIN DE LA MOTHE

CASTLE OF ST. MICHAEL, PETROGRAD (1796–1798). ARCHITECTS : BAJENOV AND BRENNA
(Formerly surrounded by a moat with drawbridge. Scene of the murder of its builder, the Emperor Paul I, in 1801.) In the foreground : Equestrian statue of Peter the Great by Rastrelli the Elder (1743)

one of the greatest of builders, and by Alexander I. All the phases of European art of the eighteenth and nineteenth centuries are reflected in the architecture and decoration of the buildings of St. Petersburg. For a couple of generations foreign architects held undisputed sway, but after the foundation, in 1758, of the Academy of Arts, which provided training for native talent, they found worthy rivals in their Russian colleagues. Moreover, foreign styles were modified by local influences, and classical architecture, especially, became so acclimatised as to deserve the name of a national style.



COLONNADE OF THE ALEXANDER PALACE, TSARSKOE SELO (1795). ARCHITECT : QUARENGHI
(Favourite residence of Nicholas II, from where he and his family were conveyed to Siberia in 1917)

Besides palatial edifices in the capital and its environs worthy to be compared with anything of the kind in Western Europe, charming country houses were built in the classic style by the nobility on their estates in various parts of Russia. Many of these " nests of gentlefolk," so attractively portrayed in Russian novels, are now only memories, having been wantonly destroyed, with all their contents, during the recent revolution.

The revolution has also struck a death-blow at St. Petersburg by causing the removal of the seat of government back to Moscow. Thus the " Petersburg period " of Russian art seems to be definitely closed. This fact—a melancholy one for lovers of the northern capital—lends additional interest to a book wherein is described the leading part which the city on the Neva, now a dethroned monarch among the capitals of Europe, played for two centuries as the centre of the artistic life of Russia.

In his concluding chapter, M. Réau discusses the present condition and future prospects of Russian art.

During the French Revolution, he observes, many artists, including some of the most eminent, never stirred from Paris. But the moral, not to speak of the physical, conditions in Soviet Russia are such that almost every artist worthy of the name has been driven to seek refuge abroad. Apart from all other considerations, the fact that bolshevist rule has caused the exodus *en masse* of practically the whole of intellectual Russia suffices alone to condemn this *régime*, at the same time revealing the secret of its weakness.

Russian art has thus been divided into two diverging currents, the artists who have emigrated being out of touch with those who have remained in Soviet Russia. The latter, in obedience to the powers that be, have endeavoured to devise a " proletarian art " to take the

THE ADMIRALTY, PETROGRAD (1806–1810). PRINCIPAL FACADE
ARCHITECT: ZAKHAROV

THE ADMIRALTY, PETROGRAD (1806–1810). ARCHITECT: ZAKHAROV
PRINCIPAL ENTRANCE. SCULPTURAL GROUPS BY SHTCHEDRIN (1812)

place of the art of the crushed and despised *bourgeois*. The attempt, says M. Réau, has signally failed.

On the other hand, the many Russian artists now living abroad have also not as yet produced anything very noteworthy.

Some time must necessarily elapse before the effect of the revolution upon art takes definite shape. A period of upheaval, misery, and ruin is not one in which we may expect to witness an artistic renaissance. It is, nevertheless, possible to hazard a guess as to some of the general lines on which art may develop in Russia in the future. The decentralising tendency of the Bolshevist revolution will presumably have the effect of calling to life new art centres in the provinces, which until now were dominated, artistically and intellectually, by the two capitals. Perhaps in the federative Russia of the future we shall witness the birth of a Ukrainian, a Siberian, and other local or regional arts. This would be of great benefit to an immense country like Russia, which "two beacons, however powerful, are not sufficient to illuminate." Furthermore, Russian art will in all probability strive more earnestly than ever in the past to become a national art. The national consciousness, which has been slumbering too long, seems to be slowly reawakening. A religious revival is already in progress, in spite of—or, perhaps, thanks to—the violent efforts of the atheist rulers of the country to destroy all religious belief, and primarily to disorganise and discredit the Orthodox Church. Similarly, the systematic stifling of patriotic feeling by internationalists, mostly of non-Russian origin, may, it can reasonably be conjectured, ultimately have the effect of rousing the latent patriotism of the people.

When the happy time comes for Russian refugees to return to their country, they will bring with them, as a result of their sojourn abroad, a keener sense of their individuality. M. Réau, who doubtless has had many opportunities in Paris of studying the mentality of these refugees, observes that never did Russians feel themselves more ardently Russian than during these years of exile and misery in foreign lands. He warns Russian artists, however, to avoid the pitfall of a too narrow-minded, chauvinistic conception of what Russian art should be. In particular, they would be badly inspired indeed, he declares, if they abjured the traditions of classic art, as bequeathed to them by St. Petersburg, and revived the old Slavophil illusion of regarding the destinies of Russia, her history, her civilisation, and her art as being subject to special laws unknown to other countries. The French author's view, it should be added, is in complete accordance with that held by the best and most authoritative Russian art critics of the present day. What Russia wants is a *national*, but not a *nationalist*, art, equally far removed from revolutionary exaggerations on the one side, and from a pseudo-mediæval reaction on the other.

Strawberry Hill

BY CHARLES E. SAYER [*A.*]

Strawberry Hill is in the market, and some account of this once famous house may interest architects.

The student of the Walpole letters who makes a pilgrimage to the place is at first surprised at its size. Either from his familiarity with great houses, or from an urbane convention of modesty, Walpole always refers to it as a small place—"a plaything house," whereas "mansion" would be nearer the mark, even before the nineteenth century additions.

Its general aspect is rather forlorn. The original stucco has been replaced by Portland cement with funereal effect, the meadows are intersected by a new road, and the whole place is hemmed in by streets of tiny houses. Altogether it has the effect of a noble of the *ancien régime* hustled by a crowd of *sans-culottes*. The garden—judging from old prints—is, however, improved since an erring footman lacerated Horace's feelings by hanging himself in it.

Within it is much easier to recapture the spirit of the letters. You enter in the oldest portion (the remains, probably, of the house built late in the seventeenth century by a retired coachman), with small, low-ceiled rooms, mount the "Baronial" stairs to the fine library, the really splendid gallery, and, finally, to the round drawing-room, which marks the end of the original house and beyond which is the nineteenth century wing.

The "Gothick" decoration, which caused such a hubbub, is, of course, only skin deep, a sort of veneer in spirit resembling the French *rococo*, but it is applied with great taste, and the effect is quite charming. Walpole and Bentley sought out forms and ornament from tombs and chantries, and paraphrased them to their liking; there is no archæological copying; it is all pure fantasy, recalling Bentley's frontispiece to Gray's *Elegy*. The fan vaulting to the gallery, for instance, copied from Henry VII's Chapel, makes no pretence to be stone; its small scale and delicate intricacy proclaim it a plaster ceiling. Much is made in the letters of the stained glass, but it is rather disappointing, mostly German and Swiss grisaille of the sixteenth and seventeenth centuries, though some of the armorial glass made for the place is surprisingly good. The only architect employed was Mr. Essex, of Cambridge, who designed the Beauclerc hexagonal closet built in 1776, the last addition to the original house, and who, perhaps, may claim the title of the first architect of the Gothic revival. The beautiful scagliola inlaid marble mantel in the round drawing-room, however, Walpole says, was copied from Edward the Confessor's tomb, "improved by Mr. Adam."

Walpole's slender shade, if it wander here, must find much disconcerting and distressing; but the vibrations of the note he struck have not yet wholly ceased.

JOURNAL OF THE ROYAL INSTITUTE OF BRITISH ARCHITECTS

The Acoustics of the Auditorium

BY G. A. SUTHERLAND, M.A.

THE subject of the acoustics of the auditorium is one of great importance to the community, and, in view of this importance, one which has received singularly little attention from physicists in this country. From time to time a more than ordinarily bad case focuses public attention on the problem ; and at such times it is customary to state that not only is the question one to which no answer has yet been propounded, but that it is a question to which science can have nothing to say. Indeed, the subject has been invested with a quite unwarranted air of mystery, so that it is common to hear the statements that two identically constructed auditoria may have quite different acoustic properties, and that any prediction of what will happen in a given case is at the best a conjecture.

Such an attitude, it need hardly be said, is an impossible one for any scientific man to adopt, and it is the purpose of this paper to dispel the atmosphere of superstition which surrounds the problem and to show not only that it is capable of solution on scientific lines, but that, in the face of great difficulty, it has been so solved, not, perhaps, completely, but so nearly completely that such a thing as an acoustic horror is quite inexcusable. The principles that theory and laboratory experiment have united in formulating have been applied extensively in practice, particularly in America, and the results, both in predicting acoustical quality in advance and in remedying defects in buildings already constructed, have been a striking confirmation of what might otherwise have been felt to be work purely of academic interest.

To understand the nature of the inquiry and to apply its results it is necessary to be acquainted with the nature of sound and the main phenomena of sound propagation. Some apology is, perhaps, needed for introducing considerations of an elementary character ; but in view of the strange opinions on the subject expressed by otherwise quite reputable persons—opinions which show that the underlying physical considerations are not appreciated—it has seemed well to devote some space to an attempt to make familiar the foundation on which the structure that is to follow is built.

The greatest physical generalisation of the nineteenth century was the doctrine of the conservation of energy, the theorem that energy is never created and never destroyed, that the changes in energy that we observe consist merely in the transformation of one kind of energy into another. In the gross mechanisms that we invent this transformation is always in the same direction, always tending to the degradation of energy, so that ultimately it is all converted into the lowest form of energy, the energy of heat. Heat energy consists of the vibrations of the minute molecules of a body, and it is the lowest form of energy because this agitation is entirely unco-ordinated and undirected. The molecules dash about hither and thither without rhyme or reason ; and in the absence of some mechanism of molecular dimensions and with molecular discrimination—something in the nature of a policeman who can regulate the molecular traffic—the energy is unavailable for our use. Sound is a form of energy, and it cannot be got rid of by being broken up or scattered, however thorough this scattering may be. It remains audible as sound unless and until it suffers conversion, either by some degrading force, such as friction, directly into heat, or into some other form which will eventually become heat.

If to a balloon or bubble containing a mixture of oxygen and hydrogen in suitable proportions a flame be applied, a sound is heard by everyone in the room in which the experiment is performed. The chemical union of the gases produces a sudden evolution of heat, and this heat causes the gases to expand. The sudden expansion of the sphere produces a compression in the shell of air just surrounding it, and this shell, being elastic, on recovery passes on the compression to the shell of air next outside it, and so the compression travels outwards in ever-widening spherical shells until it impinges on the tympanum of someone's ear, and the sensation of sound is experienced. The expansion of the original gases leaves a void or rarefaction behind, and in recovering from their compression they overshoot the mark, and by a repetition of the process the rarefaction is propagated outward on the heels of the condensation. The condensation and rarefaction together constitute what is called a wave of sound. Sound, then, is propagated by a form of wave motion, the essence of all wave motion being that while the wave itself moves forward in one direction, the particles participating in the wave oscillate backwards and forwards but do not get far from their positions of rest. In water waves the motion of the particles is at right angles to the motion of the wave, in sound waves their motion is in the same line.

A sound wave is more often produced by the continued impact of a vibrating body on the air than by a single shock such as we have considered. In either case the condition of producing a sound wave is that the impulse shall be sufficiently sudden, or, in other words, that the vibrations shall succeed each other sufficiently rapidly for the compression of the air to take place before it has, so to speak, time to get out of the way.

Experiment shows that sounds audible to human

beings are produced when the number of vibrations per second lies between 16 and 38,000 (for music the corresponding range is from 40 to 4,000); but the range varies with different persons and diminishes with age.

When the vibrations of a body are periodic—that is to say, when the same mode of vibration repeats itself at regular intervals, we experience the sensation of a musical tone; when the vibrations are not periodic, but irregular, then we experience a noise. If the coalman could deliver his coal so that the lumps reached the ground at a constant rate the result would be musical. As it is, the irregular delivery—*i.e.*, the superposition of sounds of different periods—produces an effect similar to that which may be produced by depressing several keys of the pianoforte at the same time. If the ticks of a watch were as rapid as 100 a second they would blend into a single note. The hum of the humming bird is the result of such a rapid regular flapping of its wings.

Experience shows that sounds of different pitches travel at the same speed in a given medium—otherwise it would be impossible to distinguish the tune played by a band at a little distance since the time would be altered. This speed in air at 60 deg. F. is about 1,120 feet per second. In water it is about 4½ and in steel about 16 times as great.

So long as the sound is travelling in a single medium it spreads out in ever-widening spheres, the direction of motion of any point of the wave front remaining the same. But so soon as it reaches the boundary of another medium in which its speed is different the wave splits up. Part of it is reflected back through the first medium and part of it is refracted or bent through the second. The laws of reflection and refraction are well known, and both phenomena play a part in determining the acoustical quality of a room, though refraction enters into the problem only in exceptional cases.

A phenomenon of great importance in certain designs of auditorium is that known as *interference*. If two waves of any kind are superposed the resulting wave is an addition of the effects of both. Should the waves be of the same length and in the same phase—*i.e.*, if condensation falls upon condensation and rarefaction upon rarefaction, then the result is an intensification of the sound. If, however, the waves be out of step by half a wave-length, so that the condensation of one falls on the rarefaction of the other, and *vice versa*, then, if the original intensities of the sounds be just equal, the two will neutralise each other, and there will be silence. This process of neutralisation, as has been said, is known as *interference*. The phenomenon is very simply observed by rotating a tuning-fork near the ear. Four times in every revolution there is silence owing to the superposition of waves out of step. This is illustrated in Fig. 1, in which the thick lines indicate the directions along which interference takes place. When a wave is reflected back upon itself from a wall there are alternate points of maximum and minimum vibration called anti-nodes and nodes respectively. These correspond to points of extra intensity and of comparative silence in an auditorium. The distance between two such nodes is half a wave-length, and their presence may readily be demonstrated with suitable apparatus.

Experiment shows that what we call the pitch of a note depends on the frequency—*i.e.*, on the number of vibrations per second. The octave of a note has twice its number of vibrations. Since sounds of all pitches travel the same distance in a second, it follows that the wave-length of the lower notes is much greater than that of the higher. As the frequencies of audible sounds vary from 16 to 38,000 per second, so the corresponding wave-lengths vary from 70 feet to about one-third of an inch.

The wave-length of a note is of great significance in connection with the next feature of wave propagation that we have to consider—*viz.*, the bending of sound round obstacles or corners, which is known as *diffraction*. This is a characteristic of all forms of wave motion and is quite familiar in the case of sound. The condition that sound shall bend round an object is that the dimensions of the object shall be comparable with the wave-length of the sound. A comparatively small object will stop a sound of very high pitch, but it requires a large one to stop a sound of low pitch, just as a ripple on the surface of water will be stopped by a rock but a long wave will bend right round it. When a powder magazine explodes the sound waves produce so much displacement in the air that they blow in all the windows in the neighbourhood. As the sound is one of low pitch, its wave-length is great, so that it readily bends round houses, and the windows are blown in, not only on the sides nearest the magazine, but also on the opposite sides. The same kind of bending takes place in the case of light; but, since there the wave-lengths are of the order of about a forty-thousandth of an inch, the phenomenon is not evident without the aid of special apparatus.

It is worth while here to note an important difference between the reflection of sound and that of light. Light is regularly reflected only from a highly polished surface. Because of the minuteness of the waves, correspondingly minute scratches produce irregular scattering. But the wave-length of low musical notes, as we have seen, may be as much as 30 feet, and scratches in depth about one-tenth of this—*i.e.*, 3 feet—and in breadth at least 15 feet will be required to produce scattering of such sounds. For speech the corresponding depth is from 3 to 5 inches, and the breadth 15 to 25 inches.

Bodies capable of vibrating can be forced to vibrate in the period of some sounding body in contact with them, a familiar instance being the case of a tuning-

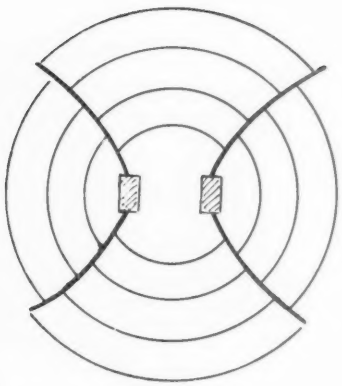


FIG. 1.—Showing lines of interference round the prongs of a tuning fork

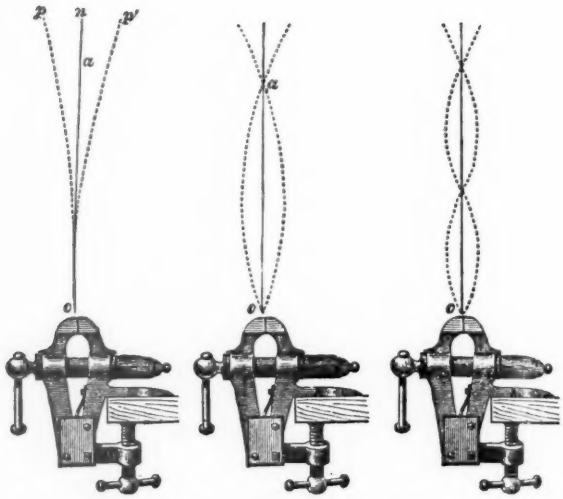


FIG. 2.—Showing different possible modes of vibration of a rod clamped at one end

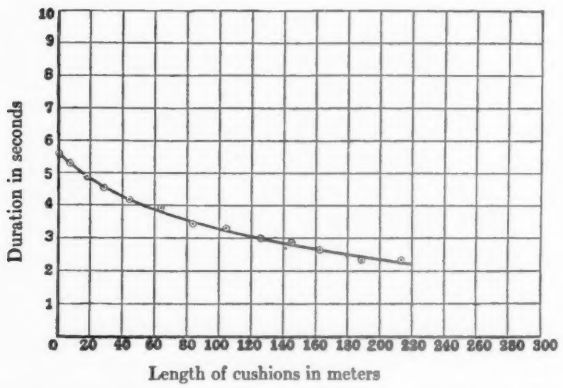


FIG. 3.—Curve showing the relation of the duration of the residual sound to the added absorbing material. (Fogg Art Museum—University of Harvard)

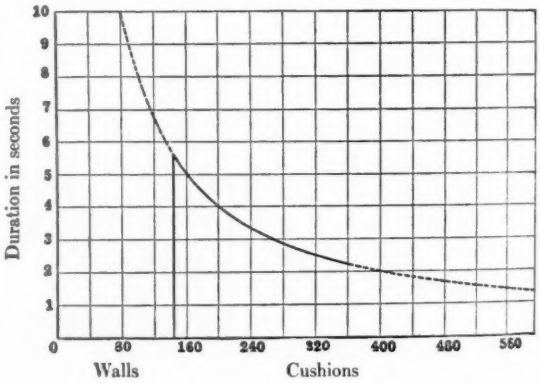


FIG. 4.—Curve illustrating the absorbing power of the Fogg Art Museum before the introduction of cushions

fork with its end on a table. It is this *forced vibration* by some sounding-board or sounding-box that produces the intensity of sound in many musical instruments. The sound of a piano string would not be audible but for the forced vibration in the wood, as is realised when a suitably isolated wire is plucked.

While a body may be forced to vibrate in the period of another, yet every body has one or more natural periods of its own to which it will most readily respond. If the bob of a pendulum be tapped gently every now and then nothing much happens, but if the taps are timed so that they always occur at the same stage of a vibration the amplitude is soon increased enormously. This is an illustration of a general principle known as *resonance*. It applies not only to sound, but to vibrations of every kind, and is familiar to-day because of the prominent part it plays in wireless telephony.

One sounding-wire will cause another of the same natural period to vibrate in unison with it. A tuning-fork will cause a column of air of the same natural period to sound with it. *Forced vibration* and resonance also play their part in the distribution of sound in an auditorium.

Musical sounds not only have loudness and pitch, they also have quality. Notes from a piano and a violin are essentially different in quality. The loudness of a note depends on the *amplitude* of the wave—*i.e.*,on the maximum distance from the undisturbed position travelled by the particles in vibration. The pitch depends on the number of waves per second, and so on the *length* of the wave ; while the quality depends on the *shape* of the wave. The simplest form of wave is that known as a sine curve. No musical instrument gives so simple a wave as that ; but an elegant mathematical theorem due to Fourier shows that the most complicated of waves can be built up by the superposition of a series of such sine waves, and an instrument called an harmonic analyser has been invented which receives the complex curve at one end, and, when the handle is turned, yields up the series of component sine surves at the other.

Whence in a musical tone do these various sine waves come ? Each must correspond to a mode of vibration, and we conclude that a sounding body must vibrate in many modes at once. That this happens may readily be shown by experiment. Fig. 2 shows different possible modes of vibration of a rod with one end clamped in a vice, and by suitable excitation these may be made to take place simultaneously. And the cause of different qualities of the notes emitted by a wire plucked at different points may be illustrated by showing the presence of different modes of vibration in the different cases. The simplest possible mode of vibration is called the fundamental, the other higher modes are called overtones. In the design of an auditorium for music it will be shown that considerations of this kind may not be overlooked.

We have now surveyed the main phenomena of sound and are in a position to consider their application to the acoustics of an auditorium. In this connection it is worth while quoting the words of Vitruvius, *De Architectura*, Liber V, Cap. VIII. (*De locis consonantibus ad theatra eligendis.*)

" All this being arranged, we must see with even greater care that a position has been taken where the voice falls softly and is not so reflected as to produce a confused effect on the ear. There are some positions offering natural obstructions to the projection of the voice—as, for instance, the *dissonant*, which in Greek are termed κατηχοῦντες ; the *circumsonant*, which with them are named περιχοῦντες ; and, again, the *resonant*, which are called ἀντηχοῦντες. The *consonant* positions are called by them συνηχοῦντες.

" The dissonant are those places in which the sound first uttered is carried up, strikes against solid bodies above, and, reflected, checks as it falls the rise of the succeeding sound.

" The circumsonant are those in which the voice, spreading in all directions, is reflected into the middle, where it dissolves, confusing the case endings, and dies away in sounds of indistinct meaning.

" The resonant are those in which the voice comes in contact with some solid substance and is reflected, producing an echo and making the case terminations double.

" The consonant are those in which the voice is supported and strengthened and reaches the ear in words which are clear and distinct."

This is interesting, because it is an admirable analysis of the problem of auditorium acoustics. To adapt it to modern usage we must substitute for the word dissonance, interference ; for the word circumsonance, reverberation ; for the word resonance, echo. The word consonance stands, for we have no other word in use to-day to express the same idea. To read such a definiteness into the words of Vitruvius is probably unjustifiable, but at least he would seem to have had the root of the matter in him.

Let us consider the simplest possible type of auditorium—a level plain with the ground bare and hard, a single person for an audience—it is clear that to a first approximation the sound spreads in a hemispherical wave, diminishing in intensity as it increases in size. If, instead of being bare, the ground is occupied by a large audience, the sound diminishes in intensity even more rapidly, as it is now absorbed. The air particles in the wave are entangled in the pores of the clothing, and by friction the energy is converted into heat. The upper part of the sound wave escapes unaffected, but the lower edge—the only part that is of service to an audience on a plain—is rapidly lost. The first and most

obvious improvement is to raise the speaker above the level of the audience ; the second is to raise the seats at the rear; the third is to place a wall behind the speaker to reflect forward the back portion of the wave. The result is, in effect, the classic theatre. These changes being made, still all the sound rising at any considerable angle is lost through the opening above, and only part of the speaker's efforts serves the audience. When to this auditorium is added a roof the average intensity of sound throughout the room is greatly increased owing to reflection downwards from the ceiling, this being especially so in the case of sustained tones, and the intensities at the front and rear are more nearly equalised. If, in addition, galleries be constructed to elevate the distant part of the audience and bring it nearer to the front we have the general form of the modern auditorium.

The three necessary and sufficient conditions of good hearing in an auditorium are uniform and adequate loudness, clearness or distinctnesss and accurate rendering. Distinctness involves freedom from overlapping in successive sounds and also freedom from extraneous noise. For accurate rendering the simultaneous components of a complex sound should maintain their proper relative intensities. So many factors contribute to the satisfaction of these conditions that the problem of assuring them is necessarily complex. But it is a perfectly determinate one. First we must enumerate these various factors and discover and define quantitatively in terms of them what we mean by good acoustics. Secondly, we must devise means by which we may estimate, again quantitatively, how far they will be realised in any planned or existing auditorium and how the necessary modifications in shape and materials may be ascertained.

When a speaker delivers an address the sound proceeds from him in waves to the boundaries of the room unless it is absorbed on the way. At the walls it may be reflected, or transmitted, or absorbed. In general, it will suffer all three kinds of treatment in relative proportions which depend on the character of the walls. Hard and smooth walls will reflect the major part of the sound, while porous and yielding walls will reflect very little. Eventually, after successive impact on different surfaces, the whole of the sound will be absorbed.

The main effects of reflection are two. If the room is not too large the first effect will be to produce the same average loudness at different points of the room. In the case of a room 40 feet square reflections will occur at least 27 times a second, since $\frac{1,120}{40}=27$. These many reflections reinforce the original sound, and so adequate consonance is assured. Consonance is the one acoustical virtue that is positive, and it is the characteristic virtue of the modern theatre. But the numerous reflections produce other qualities as well. If the walls are hard, mechanical energy is not readily imparted to them, and so little energy is absorbed at each impact. Very many reflections occur before the sound dies out. This produces slow decay or *reverberation*, which is the most common defect in modern audience halls. Consonance makes for loudness, but reverberation detracts from distinctness.

It is common to credit the classic theatre with perfect acoustics, probably because it is easier to associate perfection with something distant in space and time and of which one has no personal knowledge. The reputation is in most respects deserved, but contemporaneous evidence unites with physical theory in making it impossible to accord the theatre unqualified praise. Travellers make a point of testing such ruins of classic theatres as remain, and find the perfection which they are already convinced is there. If the acoustics are perfect now, they certainly cannot have been so originally, when complete scæna and the enclosing walls were present. But in any case the absence of a large audience vitiates the test as it would in a modern theatre, though the effects are different in the two cases. The presence of an audience diminishes the reverberation, and it diminishes the loudness of the sound. In the classic theatre, occupied or unoccupied, there was little reverberation ; that, in fact, was its merit. But the fact that there was little reverberation is also evidence that there was only slight architectural reinforcement of the voice.

We are not, however, dependent on such *a priori* considerations for our evidence. That there was insufficient consonance is shown by the use of megaphone mouthpieces in both the tragic and the comic masks, and by Vitruvius's instructions for the use of resonant vases. The megaphone mouthpiece must necessarily have been destructive of the finer shades of enunciation, and, presumably for this reason, was seldom used. Vitruvius's instructions for the location of resonant vases are very explicit. The device was rarely tried, and could not have accomplished its purpose. But, though neither of these two schemes proved satisfactory in practice, their very suggestion is evidence that the acoustics of the classic theatre did not satisfy its contemporaries, and that the defect for which a remedy was sought was lack of consonance.

Just as the prime defect of the classic theatre was the lack of that virtue most prominent in the modern auditorium, so reverberation, the commonest defect of the present day, was in the nature of the case almost entirely lacking in the theatre of old. Consonance and reverberation go hand in hand ; their demands are contradictory, and in any given case a balance must be struck between the two.

It is typical of the attitude that has been adopted to the whole question that the attempt is sometimes made to-day to cure the excessive reverberation in churches by introducing vases. The argument evidently has been : The Greek theatre had good acoustics and it

had vases; let us have vases that we, too, may have good acoustics. And this quite regardless of the fact that the defects in the two cases are the direct opposite, and apart altogether from any consideration as to whether the vases contributed at all to the good acoustics of the classic theatre.

When a source commences to emit sound waves, the sound heard first of all grows in intensity, and during this growth the rate of emission is greater than the rate of absorption. Then a maximum is reached, and in this condition energy is being emitted and absorbed at the same rate. This condition persists until the source is stopped, when the absorption continues, and the sound gradually dies away to inaudibility. Both the growth of the sound and its decay are due to the many reflections it undergoes. The laws of this growth and decay, and on what factors they depend, are most clearly brought out by the theoretical analysis of Jaeger. Jaeger's treatment shows that for satisfactory acoustics there should be some relation between the size of a room and the intensity of the sound for which it is to be used. Thus a room too large it is inherently impossible to fashion for satisfactory acoustics in the case of sounds of limited strengths. Adequate loudness can be secured only by conditions which make for excessive reverberation.

Further, he showed that the rate of growth of a sound and its rate of decay depend on the ratio of the total surface of a room to its volume; and this explains why it is that two rooms having the same proportions but different in size are not acoustically similar; for the ratio of surface to volume changes with changing size.

The effect of reverberation on speech is easily understood. A speaker can deliver three syllables in a second. If the reverberation of a sound spoken in an ordinary tone of voice lasts for five seconds in any given room, then the sounds of fifteen successive syllables will be heard simultaneously, a state of affairs that militates quite intolerably against our second desideratum—*viz.*, distinctness. Clearly, then, for speech reverberation must be reduced to the minimum consistent with adequate loudness. In a small room this should be less than one second. In a large room a longer period is tolerable, probably because in a large room the speaker realises the necessity of clear and slow enunciation. In music the case is slightly different. Reverberation produces an effect similar to that of the loud pedal in a piano. Some prolongation and blending of notes in music is desirable, but the mixing of words in speech is never an advantage. If a hall is to be used for both, a middle course must be steered. The reverberation must be made somewhat too long for speech, somewhat too short for music, yet fairly satisfactory for both.

Besides consonance and reverberation, reflection may in larger rooms produce an *echo*. An echo occurs when the wall from which a reflection takes place is at such a distance that the impressions formed by the direct and reflected sounds are quite distinct. The ear can appreciate two sounds separately if the interval between them is greater than a fifteenth of a second. As the velocity of sound is 1,120 feet per second, this gives the minimum distance of the reflecting walls as $\frac{1,120}{2\times 15}=37$ feet. The farther off the wall the more distinct is the echo. In the case of a curved wall the reflection is of a special character. As will be shown later, the curve exercises a focusing action and produces regions of undue intensification and comparative silence. It is almost inevitably a menace to good acoustics. Echoes are clearly inconsistent with distinctness, and sound foci, even if echoes are absent, are inconsistent with uniform loudness. Echoes and sound foci must both be eliminated as completely as possible.

The general principle underlying the cure of excessive reverberation is the introduction of material which will absorb the sound. The reverberation in an empty house is notorious, and the improvement that can be effected by hanging heavy curtains is also a matter of common knowledge. Some of the sound energy in a room will escape through open windows, some will be used up in imparting mechanical energy to the walls, some will pass directly by friction into heat. A hiss is very soon killed by air friction, but in a lower sound this effect is almost negligible. The frictional effects are, however, greatly increased by the presence of porous walls and hangings. No mere modifications of the surface by the introduction of irregularities are of any avail in this connection. The breaking up of smooth surfaces by relief work may eliminate echoes, but it has no effect on reverberation, except in so far as the total surface is increased by the breaking up.

The first systematic study of reverberation was commenced by W. C. Sabine, of Harvard University, in about 1896, and five years later a series of papers appeared embodying the results of this investigation. The investigation commenced with the practical problem of a lecture room in the Fogg Art Museum in the University of Harvard, where a word spoken in an ordinary tone of voice could be heard for about $5\frac{1}{2}$ seconds afterwards. An organ pipe blown at constant pressure was used as source, and the time the sound took to die down to inaudibility when the blowing was stopped was noted. Cushions from a neighbouring lecture theatre were then introduced, and the new time noted. This process was continued until the time of decay to inaudibility had fallen to 2·2 seconds. All the experiments were necessarily carried out at night.

Preliminary experiments showed that there was excellent agreement between the results obtained by the same experimenter at different times and between different experimenters at the same time, that the time of decay was practically the same at all parts of an auditorium, and, thirdly, that the efficacy of an absor-

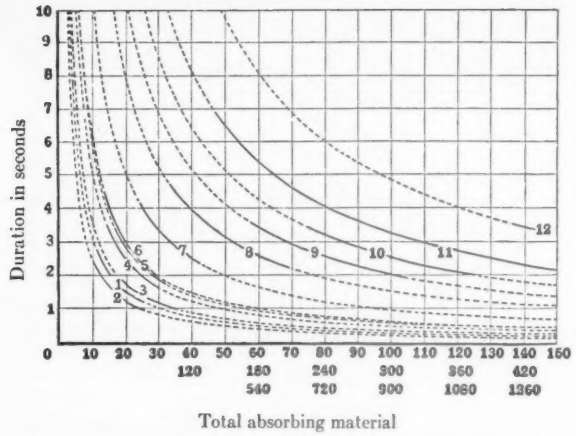


FIG. 5.—Showing the single type of the reverberation curve for rooms of different sizes. (Three different scales are used to reduce the size of the diagram)

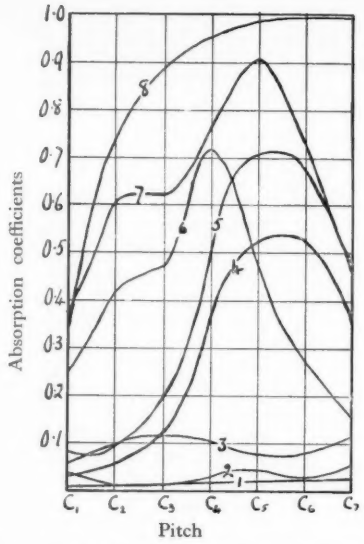


FIG. 6.—Showing the absorbing powers of different materials

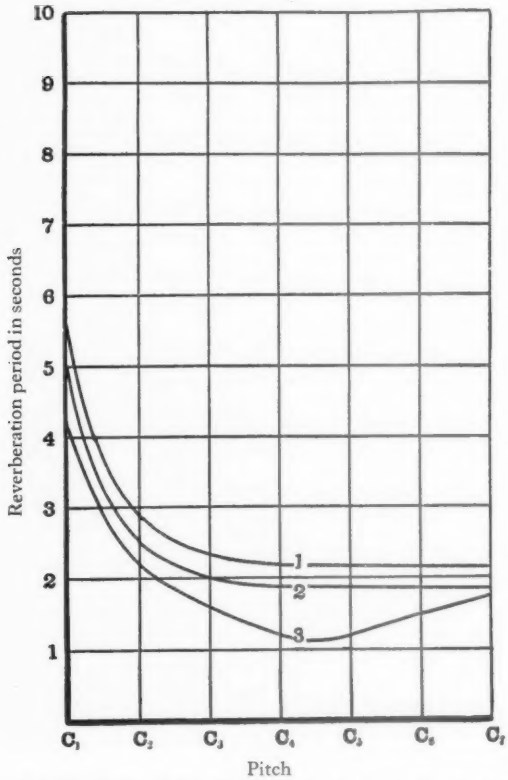


FIG. 7.—Showing the effect on reverberation in the Little Theatre, New York, of the introduction of absorbent material

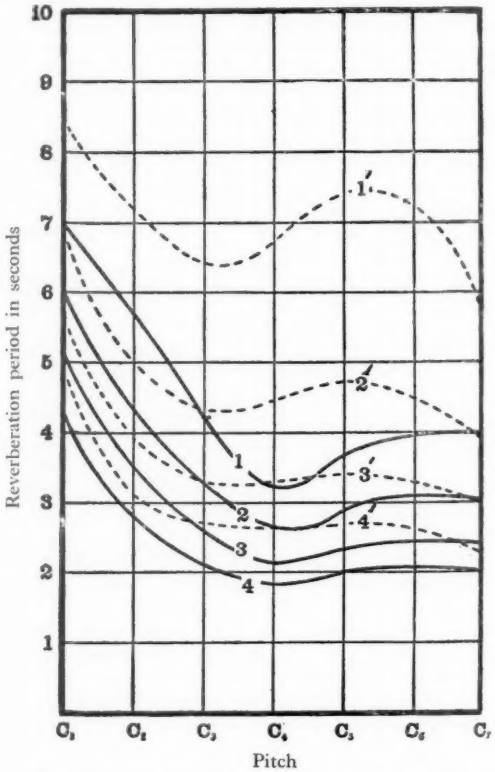


FIG. 9.—Showing the effect on reverberation for different numbers of persons present of lining ceiling and upper part of walls with felt. St. Paul's Cathedral, Detroit. The dotted curves represent the conditions before, the full curves after treatment

bent *in reducing the period of reverberation* is practically independent of its position. The settling of these three points made subsequent work much easier, since any locations could be chosen for source, observer and absorbent.

The results in the case of the Fogg Art Museum are best shown by means of a curve (Fig. 3). The nature of the dotted extension of the curve in both directions, as shown in Fig. 4, will be understood when one considers that if one filled the whole room with cushions the sound would be absorbed instantaneously—*i.e.*, the time would be zero—whereas if there were no absorbent in the room the sound would go on for ever—*i.e.*, it would be infinite. The reason why the time is not infinite when no cushions are present is because the room itself, (the walls, the ceiling, the floor) has an absorbing power. Clearly, then, the curve will tell us the absorbing power of the room in metres of cushions. In this case the value is 146 metres.*

By substituting various materials in turn for the cushions Sabine was able to compare the powers of various absorbents with corresponding areas of Sanders Theatre cushions, and thus with each other. Now, the cushions of a particular lecture theatre in America are clearly not very useful units in which to express absorbing powers in England, and Sabine's next work consisted in finding a comparison between the absorbing power of these cushions and an equal area of something which is readily available anywhere—*viz.*, the open window. The open window may be regarded as a perfect absorber—the only perfect absorber of sound. Experiment showed that the absorbing power of an open window was proportional to the area of the opening, and the next experiments sought to express the value of the cushions as absorbents in square metres of complete absorption. These experiments were attended with great difficulty, for the slightest external noise would upset them, and they were therefore impossible in summer, even at night, owing to insect noises, and could be carried out only on winter nights when there was but the slightest wind. So that, though the open window is the important standard of comparison, the cushions are much more convenient to use in practice when once their absolute value has been determined.

Before quoting the results of these experiments, we may go on to consider further similar experiments in various rooms. These are the more significant because of the diversity of the shapes, sizes and furnishings of the rooms chosen. All the rooms yielded the same type of curve as shown in Fig. 5, although the volumes varied from 65 to 9,300 cubic metres. Anyone with a slight knowledge of mathematics looking at these curves would immediately conclude that they were rectangular hyperbolæ, and investigation shows that this assumption fits the facts very closely. The characteristic property of a rectangular hyperbola plotted like this is that the product of the distances of any point on it from the axes is the same quantity for any point on the curve. This constant quantity is called the parameter of the curve. So that, expressed in words, each of these curves simply means that for a given room the total absorbing power $\times$ time of reverberation is constant. In other words, if we increase the absorbing power A, the time T is proportionally decreased. Further, an examination of the parameters of the different curves shows that every one is proportional to the volume of the appropriate room, so that for any room we have the relation :

$$\frac{\text{Absorbing Power} \times \text{Time of Reverberation}}{\text{Volume}} = \text{a constant quantity.}$$

The value of this constant quantity depends, of course, on the initial intensity of the sound and on the units adopted for absorbing power. By comparing the times of reverberation, when 1, 2, 3 and 4 similar organ pipes were used, Sabine was able to show that the sound he was using had an intensity one million times the minimum audible intensity ; and that in this case the constant works out at 0·164 if the absorbing power be reckoned in square metres of complete absorption and the volume of the room in cubic metres. If square feet of complete absorption and cubic feet of volume are the units, then the constant is 0·050. The following table gives most of the results obtained by Sabine, using an organ pipe of pitch C4, 512 :—

	For Feet or Metres.
Open window	1·000
Brick wall, 18-inch thick, set in cement	0·032
Brick wall, 18-inch thick, set in cement, painted two coats oil	0·017
Plaster on wood lath, 2-inch air space, studding at 14-inch centres	0·034
Plaster on wood lath, 2-inch air space, studding at 14-inch centres, with $\frac{1}{8}$-inch finishing coat	0·028
Plaster on metal lath, 2-inch air space, studding at 14-inch centres	0·033
Plaster on hollow tile, $\frac{5}{8}$-inch coat and $\frac{1}{8}$-inch finishing coat	0·020
Glass, single thickness	0·027
Wood sheathing, $\frac{5}{8}$-inch pine on studding at 14-inch centres	0·104
Akoustolith tile	0·382
Jute felt 1·1 cm. thick	0·18
Jute felt 2·2 cm. thick	0·54
Jute felt 6·6 cm. thick	0·77
Hair felt 2·5 cm. thick	0·52
Hair felt 2·5 cm. thick mounted 6 inches from wall	0·68
Linoleum, loose on floor	0·12
Cork 2·5 cm. thick, loose on floor	0·16
Oriental rugs (extra heavy)	0·29
Carpet 0·8 cm. thick	0·20
Cheese cloth	0·019
Cretonne cloth	0·15

* It should be remarked that the air itself acts as an absorbent owing to the heat changes involved in its compression and rarefaction, but this effect is far too small to affect noticeably the reverberation period for any except the highest pitched of audible sounds.

Shelia curtains	0·23
Audience (per square metre or square foot as ordinarily seated)	0·96

SPACIAL UNITS.

	For Feet.	For Metres.
Audience per person as ordinarily seated	4·73	0·44
Audience per isolated man	5·16	0·48
Audience per isolated woman	5·80	0·54
Ash chair	0·17	0·016
Cloth cushion to cover a single seat	1·45	0·135
Hair cushion to cover a single seat	1·77 to 1·93	0·165 to 0·18
Elastic cotton (cotton wool ?) cushion, covered canvas and short nap plush	2·04	0·19
Upholstered chair (hair and leather)	3·22	0·30
Upholstered settee (hair and leather) per seat	3·01	0·28

Sabine's experiments did not by any means cover the whole range of building materials, and work is necessary to measure the coefficients for materials commonly used in England. But where a particular material has not been worked out the absorption coefficient may be taken as that of whatever material is nearest in character to the one being used, and the error in doing this may be shown in the case of hard surfaces to be negligible.

The practical application of this work can best be illustrated by working out an example, and we may take the first hall to which the application was made in advance of construction—*viz.*, the New Boston Music Hall.

We have not yet discussed the best period of reverberation for a hall used for orchestral music, though we have seen that it will certainly be desirable to have a longer period than for speech, and musical experts complain more often that it is too short than too long. In the preliminary discussion of the New Boston Hall an examination of the plans of numerous buildings known to be satisfactory showed that their reverberation was much greater than in the usual theatre for drama. The final discussion was based only on two buildings, the Old Boston Music Hall and the Leipzig Gewandhaus. The first intention was to copy the Leipzig Gewandhaus, which was known to have good acoustics, on a larger scale. "The often repeated statement that a copy of an auditorium does not necessarily possess the same acoustical qualities as the model," says Sabine, "is not justified. The fact is that exact copies have rarely been made and can hardly be expected. Constant changes and improvements in the materials used for interior construction in the line of better fireproofing have led to the taking of liberties in what were probably regarded as non-essentials. This has resulted in a changed absorbing power of the walls. Our increasing demands in regard to heat and ventilation, the restriction on dimensions enforced by location, the changes in size imposed by the demands for different seating capacity, have prevented in different degrees copies from being copies and models from successfully serving as models. So different have been the results under what was thought to have been safe guidance, but a guidance imperfectly followed, that the belief is current that the whole thing is beyond control. Had the New Boston Music Hall been enlarged from the Leipzig Gewandhaus to increase the seating capacity 70 per cent., which, preserving the same proportions, would have meant doubling the volume, and then built, as it is being built, according to the most modern methods of fireproof construction, the result, unfortunately, would have been to confirm the belief, as will presently be evident." Fortunately, calculation was applied in advance of construction, and the acoustic comparison of the three halls as regards reverberation is as follows :—

Materials.	Leipzig Gewandhaus.	Old Boston Hall.	New Boston Hall.	Absorption Coefficient.	Leipzig Gewandhaus.	Old Boston Hall.	New Boston Hall.
	Number of Units (Metres).				Absorbing Powers.		
Plaster on Lath	2,206	3,030	1,040	0·033	73	100	34
Plaster on Tile	0	0	1,830	0·025	0	0	46
Glass	17	55	22	0·027	0·4	1·5	0·6
Wood	235	771	625	0·061	14	47	38
Drapery	80	0	0	0·23	18	0	0
Drapery	0	4	0	0·15	0	0·6	0
Audience	1,517	2,391	2,579	0·44	667	1,052	1,135
Orchestra	80	80	880	0·48	38	38	38
Totals					810	1,239	1,292
Volumes (Cubic Metres)	11,200	18,400	16,200				

The volumes and the total absorbing powers being determined, we can now calculate the times of reverberation from our formula :

$$T = \frac{0{\cdot}164\ V}{A}$$

which gives us as the times in seconds :

Leipzig Gewandhaus	2·30
Old Boston Music Hall	2·44
New Boston Music Hall	2·31

In other words, the new hall, although having a seating capacity for over 1,000 more than the Gewandhaus and nearly 200 more than the old hall, has a reverberation period between the two, and much nearer that of the Gewandhaus.

It is worth while contrasting this with the result that would have been obtained had the original plan been followed of reproducing the Gewandhaus on an enlarged scale. Assuming perfect reproduction of all proportions with similar materials, the volume would have been 25,300 cubic metres, and the absorbing power 1,370, resulting in $T = 3{\cdot}02$, a period considerably in excess of that chosen.

It has been pointed out that Sabine's table gives no values of absorbing powers for many of the building materials commonly used in this country. As has been said, research is necessary in this direction ; but in the case of hard materials it will be sufficiently accurate if we assume the value of a material similar in character,

the reason being that the contribution of the hard surfaces in a room to its absorbing power is usually a very small proportion of the whole. Suppose, for example, we are dealing with stone, marble or concrete. The absorption coefficient will certainly be less than that of hard plaster, for which the coefficient is 0·028. If we assume the value 0·020, and subsequently it is shown that the true coefficient is 0·016, then our error in the absorbing power of the hard surfaces is 25 per cent. But, to take the London County Hall as an example, the contribution of the hard surfaces to the whole absorbing power is only about 7 per cent. So that the error involved in the assumption is only 25 per cent. of 7 per cent—*i.e.*, 2 per cent. In other words, a calculated reverberation of 2·04 might mean a true reverberation of 2·00—quite a negligible difference.

Sabine's experience in connection with the New Boston Music Hall led him to suppose that what in the opinion of musical experts constituted desirable acoustics would be found to be accurately associated with a fixed period of reverberation for a given class of music ; and in 1902 he commenced a series of experiments on this point. At the recently built New England Conservatory of Music was a number of small rooms with plain wooden furniture which were to be used for practising. Under Sabine's direction, a committee of musical experts listened to piano music in each room in turn, and in every case cushions were introduced until the critics expressed themselves satisfied with the acoustics. The times of reverberation were afterwards measured in the manner already described, and the results are set forth in the following table :—

Room Number.	Volume.	Absorbing Power of Room	Persons Present.	Absorbing Power of Clothing.	Metres of Cushions	Absorbing Power of Cushions	Total Absorbing Power	Reverberation in Seconds.	Remarks on Reverberation.
1	74	5·0	0	0	00	0	5·0	2·43	Too great.
		,,	5	2·4	00	0	7·4	1·64	,,
		,,	,,	,,	13	12·8	20·2	0·60	Too little.
					11	10·1	17·5	0·70	Better.
					8	7·3	14·7	0·83	,,
					6	5·5	12·9	0·95	Approved.
					4	3·6	11·0	1·22	Too great.
2	91	6·3	0	0	0	0	6·3	2·39	Too great.
			6	2·9	0	0	9·2	1·95	,,
					7	6·4	15·6	0·95	Too little.
					5	4·6	13·8	1·10	Approved.
3	210	14·0	0	0	0	0	14·0	2·46	Too great.
			7	3·4	0	0	17·4	2·00	,,
					12	11·0	28·4	1·21	Better.
					15	13·7	31·1	1·10	Approved.
4	133	8·3	0	0	0	0	8·3	2·65	Too great.
			7	3·4	0	0	11·7	1·87	,,
					6	5·5	17·2	1·26	Better.
					10	9·1	20·8	1·09	Approved.
5	96	7·0	0	0	0	0	7·0	2·24	Too great.
			4	1·9	0	0	8·9	1·76	,,
					10	9·1	18·0	0·87	Too little.
					8	7·3	16·2	0·98	Better.
					5	4·6	13·5	1·16	Approved.

Extracting from this table the times of reverberation when the acoustics were declared satisfactory, we have :

	Decay Period (seconds).
Room 1	0·95
Room 2	1·10
Room 3	1·10
Room 4	1·09
Room 5	1·16
Mean	1·08

This result is most interesting, as we see that the maximum departure from the mean is 0·13 seconds and the average departure only 0·05 seconds. The greatest deviation occurs in the case of Room 1. In this room only was it suggested carrying the experiment further when an approved condition had been reached—*viz.*, by removing two more cushions. The reverberation period was then 1·22 seconds, and was declared unsatisfactory. Now, 1·22 seconds is further above the mean than 0·95 is below. Had one cushion been removed instead of two the result might have been closer to the mean value. In every case the chosen condition came nearer to the mean value than any other condition tried. Inspection of the large table shows that there was considerable diversity in the rooms as regards size, furnishing and the number of persons present. The numbers of cushions that had to be introduced to produce satisfaction were 6, 5, 15, 10, 5, so there could be no question of prejudice. In three cases the final condition was reached from overloading, in one from underloading. Also, before the experiments no explanations were given of the method to be pursued. This surprising accuracy of musical taste is probably the explanation of the rarity with which it is entirely satisfied, particularly when architectural designs are left to chance in this respect.

The particular results of these experiments, *viz.*, the approval of a reverberation period of 1·1 seconds, is of importance, as it may be taken as the standard value for desirable results in the case of chamber music.

Sabine next extended his experiments to sounds of varying pitch. To explain the necessity for this he cites the following example :—

" In an empty room with hard walls such as a church the reverberation for a violin (middle register) and a double bass viol are about the same. The introduction of cushions reduces the reverberation for both, but in different proportions, so that the reverberation for the double bass is now twice that for the violin. The presence of an audience increases the disproportion still further. Since a difference of 5 per cent. in reverberation is a matter for the approval or disapproval of musicians of critical taste, the importance of considering these points is obvious." A further point of which account must be taken is the composite character of a musical tone. As we have seen, the quality of a tone

depends on the relative intensities of the overtones present, and it has been customary for physicists to regard these relative intensities as dependent simply on the source of sound. Primarily, of course, this is true. But, while the source determines the relative intensities in the issuing sound, the intensities as heard depend not merely on that, but also to a surprising degree on the room itself. Thus, with an 8-foot organ pipe, used by Sabine, for which the overtones were pronounced in an empty room, the introduction of felt reduced the ratio of the first overtone to the fundamental by 40 per cent., that of the third overtone by 50 per cent., and that of the fourth by 60 per cent. With a 6-inch pipe, on the other hand, the effect was to accentuate the overtones ; whereas all notes below the 6-inch fundamental were purified. The effect of an audience was still different—*viz.*, to purify all notes up to C4, 512, and to have very little effect on tones above this. For C1, 64, the first overtone was decreased 65 per cent. relative to the fundamental, and the second 75 per cent.

The musical effect will thus be injured or improved according to circumstances. The mixture stop in an organ is designed to be rich in overtones, the night-horn stop to be specially pure ; and it may happen that the room in which they are sounded will completely alter the intended effects. To determine the balance must lie with musicians, and it is important that the judgment of musical authorities should be gathered in available form. So far as the writer knows, this has never been attempted.

The chief results obtained by extending the investigation to cover the whole musical scale are most conveniently summarised by the curves in Fig. 6. Here absorption coefficients—*i.e.*, square metres of complete absorption per square metre of the substance considered (or square feet per square foot)—are plotted against the pitch of the note used :—

Curve (1) is for a painted brick wall.

Curve (2) is for plaster on tile with a finishing coat.

Curve (3) is for wood panelling ($\frac{5}{8}$-inch pine on studding at 14-inch centres).

Curve (4) is for Akoustolith tile, manufactured by the R. Guastavino Co., New York.

Curve (5) is for a special hair felt manufactured by the John Manville Co., New York.

Curve (6) is for hair cushions covered with canvas ticking and thin leatherette.

Curve (7) is for elastic cotton (cotton wool ?) cushions covered with canvas ticking and short nap plush.

Curve (8) is for audience (per square metre or square foot, as ordinarily seated).

It will be noted that plaster walls absorb hardly any sound. Wood panelling is slightly more effective, but for high absorbing power it is necessary to use some specially prepared material, such as the felt or tile specified. The former is a rather more efficient absorber, and is much cheaper. It has to be covered by some form of decorative tapestry. The tile, on the other hand, fits in better with most decorative schemes, as it can be supplied in any colour, and requires no covering. It does not collect dust to the same extent that the felt does, nor is it liable to take fire.

As reverberation is by far the most common defect in audience halls to-day, it may be interesting to discuss the case of a room which is typical of many. The library in the department of architecture at University College, though a fairly small room, is known to have poor acoustics. When a committee is held in it members seated at opposite ends of the table have difficulty in hearing one another. One's first impression on entering the room is that it is bare, and, therefore, that the defect is probably due to excessive reverberation. The time taken by the noise of clapping the hands to die out confirms this impression ; and on a rough test of this sort the reverberation period was guessed at something over two seconds. The acoustic analysis of the room gave the following results :—

Volume : 265 cubic metres.

PERMANENT FACTORS.

	Areas, Square Metres.	Coefficients.	Absorbing Power.
Plaster	175	0·025	4·4
Wood	62	0·06	3·7
Glass	22	0·027	0·6
Linoleum	50	0·12	6·0
Chairs (units)	18	0·016	0·3
Total			15·0

TEMPORARY FACTORS.

	Absorbing Power.	Totals.
6 persons (3 men and 3 women) isolated	3·1	18·1
18 persons (9 men and 9 women) isolated	9·1	24·1
50 persons seated as an audience ..	22·0	37·0

The corresponding times of reverberation are :—

	Seconds.
Empty room	2·9
Six persons present	2·4
Eighteen persons present	1·8
Fifty persons present	1·2

In a small room the reverberation should be reduced to one second or less if possible, so that at present it would hardly be satisfactory even with fifty persons present. The walls of this room are broken up by windows and bookcases, and the obvious places to put absorbing material are the ceiling and the floor. Felting the ceiling would be more difficult and less sightly than laying a carpet. It is worth while considering what difference would be made by removing the linoleum and replacing it by a fairly thick carpet laid on felt.

The corresponding increase in absorbing power would be: $50 \times 0{\cdot}38 = 19$ units, which gives as the new reverberation periods :—

	Seconds.
Empty room	1·3
Six persons present	1·2
Eighteen persons present	1·0

These values are not too low for speech in a small room. The laying of this carpet has not yet been carried out, but that it would have the desired effect there can be no question. Evidence for this conclusion must, however, be sought farther afield.

A suitable example is that of the Little Theatre in New York, to which calculation was applied in advance of construction. The purpose of this auditorium was the production of plays which could be adequately rendered only by the most delicate shades of expression, a purpose which made low reverberation over a fair range of the scale very desirable. The theatre was to seat only 300 people, and there was the important assurance that every seat would be occupied at every performance.

FIG. 8.—ST. PAUL'S CATHEDRAL, DETROIT

The first calculation, made from the initial pencil sketch, yielded curve (1) on Fig. 7. This would not have been in excess of the reverberation in many

theatres not specially bad, but here it was desired to have exceptional quality. Changes in shape were next made, which reduced the volume and yielded a condition represented by Curve (2). Acoustic felt was then applied in panels on the side and rear walls. The resulting reverberation is given by Curve (3).

As a second case of the application of the method to the reduction of reverberation we may take the case of the St. Paul's Cathedral in Detroit. In a room of the conventional rectangular pattern it is easy to apply the reverberation formula, and it matters little as far as reverberation is concerned where the absorbing material is placed. There is, however, a strategy of the subject, and one case in which special consideration is necessary may occur in a cathedral, such as this, where the nave, moderately narrow in the clerestory, was broad below owing to its extension by side aisles. Simply to calculate the total volume in this case would not have given the correct impression. But the system might be regarded as two simply connected spaces, one broad and absorbent when a large audience was present, the other narrow and highly reverberent. To correct this, felt, highly efficient acoustically, was placed in the panels on the ceiling, as shown in Fig. 8. Further improvement was made by extending the treatment partly down the walls. The original decorative design for the ceiling was carried out on the covering of the felt and the marked effect of the treatment of the reverberation is shown by the curves on Fig. 9. The dotted curves represent the conditions of the room for different sizes of audience before the treatment, the full curves the corresponding conditions after the treatment. Another case in which such treatment was successful, though undertaken only after the building was complete, is provided by the Hall of the House of Representatives in the Rhode Island State Capitol at Providence, which is illustrated in Fig. 10. Here the walls were of stone to about half the height of the room. Above that they were of plaster between stone pillars. The difficulty was reverberation, but, owing to the proportions of the room, reverberation of a special character. It was met by placing a suitable felt on the plaster walls between the columns and covering it with a decorated tapestry.

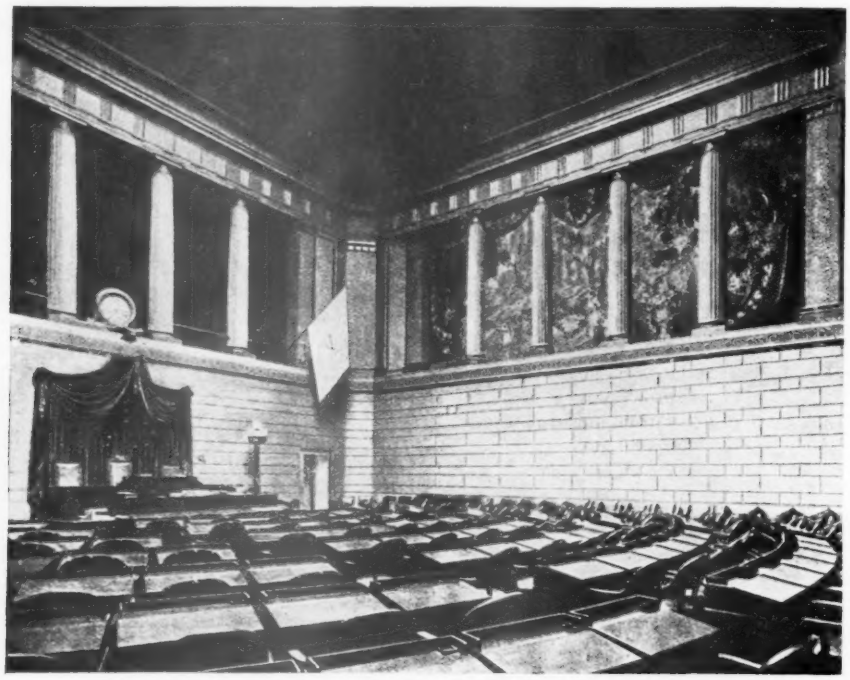


FIG. 10.—HOUSE OF REPRESENTATIVES, RHODE ISLAND STATE CAPITOL, PROVIDENCE, R.I.

(To be continued.)

Grateful acknowledgments are due to the Harvard University Press for permission to use numerous diagrams from Sabine's "Collected Papers on Acoustics" (1922) and to Messrs. F. Vieweg & Son, Brunswick, for similar permission in the case of Michel's "Hörsamkeit grosser Räume" (1921).

The Gothenburg International Town Planning Exhibition and Conference

BY THE R.I.B.A. DELEGATE

The great exhibition at Gothenburg must be regarded as a notable achievement for a city of about 200,000 inhabitants; and the Town Planning Exhibition, held in connection with it and with the Conference of the International Garden City and Town Planning Association, was no less a success. Of the exhibition generally, much has been written in the English Press by those who have doubtless devoted more time to seeing it than I was able to spare from the Town Planning section. But a word must be said as to its lay-out and its architecture. The promoters had the advantage of working in a city which has, since 1866, been developing under town planning control. For many years that control has been exercised under the guidance of Dr. Lilienberg, an engineer with much of the born architect in his make-up, well remembered for his personality, his paper and his exhibits, by those who attended the R.I.B.A. Conference and Exhibition in 1910.

It was very interesting, revisiting the city after a lapse of eleven years, to note the progress made; past plans have been realised; new garden suburbs, then only planned or started, now afford attractive homes for many colonies of people; public buildings, then only located, now justify their careful placing by the extent to which they adorn the city or stand out as prominent landmarks from the sea.

Gothenburg is indeed a standing proof of the advantage of town planning and its effectiveness to avoid evils and to secure advantages, for it is a most convenient and attractive town. As a consequence of the care exercised in the past and the definite plans thought out for the future, the exhibition has been able to take its place as an incident in an orderly development. It has derived distinction from its incorporation in the city plan, and has materially assisted towards the realisation of many of the practical and cultural projects of that plan. The main entrance to the exhibition forms the termination of one of the chief radial avenues from the centre of Gothenburg, at the point where it strikes the steep hillside and must therefore terminate or diverge as a traffic way. The lay-out and permanent portions of the buildings will form the commencement of a square or *place* to be occupied by cultural and educational buildings required for the city. The site of the central group of the Exhibition is both steep and rocky. Great skill and taste have been shown by the architects in the combination of the different sections of the exhibition, with the opportunities of the site, to create dignified, or charmingly intimate, groups of buildings of great architectural interest. Some of the buildings, it is true, display a degree of originality in form, proportion, and character, which one would be disposed to criticise in ordinary circumstances; but such originality is confined to some of the temporary buildings, in which experiments may perhaps legitimately be made with less strict regard to traditional forms, and less restraint generally, than would be considered incumbent on the designer of any permanent structure. Be that as it may, much even of the temporary work is so delightful in its simple fitness and its adaptation to the site that one cannot but regret that it is not permanent. An old church and churchyard, erected as a setting for the exhibition of ancient Swedish ecclesiastical and memorial arts, is a gem of a kind not easily to be matched in the memories of exhibition features.

Those responsible for the Town Planning Exhibition are to be congratulated on having assembled perhaps the most important and interesting collection of plans and models which has been seen since the three great exhibitions held in 1910 in Berlin, Dusseldorf, and in London, the latter arranged by the R.I.B.A.

The collection from the various Scandinavian countries, as was only natural on this occasion, was the most complete, and conveyed to the visitor from more distant lands the freshest impressions. It was indeed encouraging to Town Planners to see how these countries are working at the problems of the growing city, and each making some individual contribution of value towards their solution. It was particularly encouraging to architects to see how fully the proper function of design in town planning is realised in most of the work.

The beautiful models of Gothenburg, one showing the past achievement, another the future projects of harbour extension and town development, were naturally among the most prominent features. Fine models also illustrated the projects for Helsingfors, the work of Arenberg and Poulsen for Christiania, including some very beautiful architectural groupings of public and of domestic buildings, and the interesting and suggestive work of Sverre Pedersen at Trondhjem and other places. These and many other exhibits show, in addition to sound town planning work, an imaginative and architectural treatment of lay-out and buildings of a very high order.

The German section included much of new interest, even to those familiar with their work. Particular mention may be made of the proposals for Berlin to

meet the changed conditions and the new laws limiting the height and density of buildings outside the line of the ringbahn ; the plans and photographs of a number of eighteenth-century industrial satellite towns and villages which were planned and developed around Berlin, and still retain their original character ; and the regional survey and planning of the great Ruhr industrial area. The latter scheme afforded a notable illustration of the power for organisation on a large scale to promote the common good of their citizens which the German municipal authorities have developed. No Town Planner can look at this most highly civilised regional survey and planning without a sense of dismay at the very uncivilised struggle which is at present devastating that same area.

The American section illustrated quite a new range of problems, partly connected with the extensive use of the motor car in towns which have adopted high buildings ; and the survey studies dealing with New York problems were particularly interesting ; there were also examples of their widespread zoning activities. Reconstruction work was illustrated by plans from France, Belgium and East Prussia. England was represented by examples of the Garden City and Housing movements, the surveys and projects of the Regional Committees, and of the practical type of municipal town planning, which is the method adopted by our country for securing the main communal requirements of future city development, while leaving the maximum liberty to the individual developer. Compared with much of the work from other countries where the plans are prepared in greater detail, English municipal town plans are certainly lacking in architectural finish and treatment ; perhaps it may be claimed that they secure some advantage on the side of practical utility, and leave more scope to the developing owner. It is not easy, however, for an architect to be content with such an explanation ; for he feels that it is an excuse rather than a sufficient reason ; and that even the main framework of the scheme must be architecturally conceived, if the site planner is to have a fair chance. It is greatly to be hoped that exhibitions like that at Gothenburg, which show in the work from so many other countries a greater appreciation of the function of design in town planning, will gradually arouse in the municipal authorities and the public of this country a sense of dissatisfaction with their rather prosaic development schemes. However practical they may be, some of these schemes give little indication of imaginative treatment of the sites, and provide few opportunities for fine architectural groupings, characteristics which were common in the projects from Norway, Sweden, Finland, and many other countries.

A number of interesting Papers were read and considered at the Conference ; but one of the most instructive features was provided by the informal discussions which took place in the exhibition. International groups of town planners, architects and others, from about 20 different countries, gathered round the chief exhibits ; having first secured an explanation from the author of the work or one of his nationals, they discussed the projects and compared the methods and style adopted, with those shown in the exhibits from other nations. These discussions were contributed to by veteran town planners like Dr. Stübben, who in spite of his 78 years is as keen as ever, and anxious to find new methods to meet the changed circumstances of the towns of his country, men actively engaged in modern town planning, like John Nolen from America ; and students like Charles Eliot, of Harvard, who brought with an honoured name fresh enthusiasm and the latest ideas from the New Country.

Perhaps the main feature which emerged from the Conference was the extent to which the members of the International Garden City movement found themselves occupying common ground with the representatives of the more official town planning activities of most countries ; typified by the meeting of Ebenezer Howard and Dr. Stübben on a common platform ! It seems clear that the time is fast coming, if not already arrived, at least so far as international gatherings are concerned, when the distinction between the propagandist garden city and the practising town planning movements will no longer be required.

It was a fortunate circumstance that Dr. Hegemann, with his encyclopædic knowledge of town planning work, and his experience of former exhibitions, enriched by some years of life in America, was available to contribute to the informal discussions, and to produce the catalogue. All who are interested in the question and were unable to visit the exhibition will find there much of value. It can be obtained from Dr. Lilienberg, Gothenburg, Sweden, price 8s. R. U.

THE PRINT SOCIETY.

The second publication of the Print Society, edited by Mr. E. Hesketh Hubbard, the founder of the Society, with an Introduction by E. Kineton Parkes, contains sixty-six full-page reproductions of etchings, dry points, aquatints, and mezzotints, as well as a few reproductions of wood blocks and lithographs. The members of the Society are to be congratulated upon the production of so much admirable work. "The Trawler," by Edward W. Charlton, "The Dying Tramp," by Percy Smith, and "The Little Vourstraatshavn," by Hugh Paton, are among the many admirable examples of the etcher's art included in the volume. Architecture forms the subject of many of the prints, including "L'Eglise Notre Dame, Caudebec en Caux," by Caroline Armington, "A Street in Paris," by E. Marsden Wilson, "Trinity College, Cambridge," by H. Sheppard Dale, which are among the best. Mr. Parkes' Introduction contains some useful suggestions with regard to the preservation, mounting and framing of prints.

Reviews

LONDON OF THE FUTURE: A CITY OF PLEASANT PLACES AND NO EVIL SLUMS. *By Thomas Edward Collcutt, P.P.R.I.B.A., Royal Gold Medallist (Architecture). Published by Leonard Parsons, Devonshire Street, London, W.C. Price 2s. 6d. net.*

A city of pleasant places and no slums! If we are to enable others to travel hopefully towards this goal we must have intelligent vision; to this must be added knowledge born of experience, and to this, sympathy. In respect of all these qualities Mr. Collcutt is well equipped for the task, and his book deserves to be thoughtfully and widely read. The King's message at the opening of Parliament four years ago supplies the text: "A great offensive must be undertaken," said His Majesty, "against disease and crime, and the first point against which the attack must be delivered is the unhealthy, ugly, overcrowded house in the mean street, which we all of us know too well." Statesmen and Churchmen were ready to join forces in making this great offensive, but, after almost five years of peace, what has been done?

Mr. Collcutt points out that all the schemes which have been put forward towards a solution of the housing problem have been considered from one point of view, that is, the necessity of forming new areas of population to an already overgrown town. They have assumed that the house accommodation must be outwards. The scheme herein presented proposes that the expansion should be upwards. There is much in favour of this argument. The Londoner of the mean street must live near his work. Put him outside London, and his daily scramble for standing room in tram or bus, to and from his home, adds immensely to his discomfort and expense. Moreover, he is fond of London.

The scheme for the building of "pleasant places" begins with the construction of a South Embankment. At present London proper hardly extends across the river: there is an enormous difference between the land values on the north and the south sides. The part of Lambeth facing the river, extending from the London County Hall to Waterloo Bridge, and as far back as York Road, is occupied chiefly by wharves and warehouses, with a certain number of mean streets. To provide accommodation for the dwellers of other slum areas, this site should be cleared, and upon it could be built well-arranged systems of flats for the families of manual and other workers—eight- or ten-storey flats, furnished with passenger lifts, central heating, and domestic hot-water circulation. The children could have playing grounds on the roofs, with emergency gates between one roof and another. York Road would provide the opportunity of good shop frontage, with residential flats at higher rentals above.

For the methods by which such a scheme could be successfully accomplished the reader must be referred to the book. Mr. Collcutt believes that his plan would form the kernel of a sound undertaking, giving a good return in dividends upon the initial outlay.

Another chapter in the book deals with the suggestion of the removal of Charing Cross Station from its present site to a position on the opposite side of the river, and connecting the two sites by a structure on the principle of some of the mediæval bridges. Instead of the ordinary bridge, exposing the pedestrian to the weather, the structure across the river would form a street, with covered colonnades, shop frontages on either side, and two storeys of residential flats over. The scheme has great possibilities, and there is much in it that is attractive. It can be carried out, Mr. Collcutt believes, with great advantage to the whole community if the "powers that be" will use that corporate common sense with which God, sometimes, endows them. P. LESLIE WATERHOUSE [*F.*].

SIR CHRISTOPHER WREN. *Scientist, Scholar and Architect. By Sir Lawrence Weaver, K.B.E., F.S.A., Hon. A.R.I.B.A. [London: Published at the offices of Country Life, Ltd.*]

This is a little book written largely; on that count it ranks not the least among the tributes paid to the memory of a man who was sufficient for his time and posterity. In his preface Sir Lawrence Weaver hints at the magnitude of the task awaiting the future editor of a definitive "Life and Works," for such a book will indubitably have to be written; the hint, if one may be permitted to say so, carries with it the desire for time and opportunity to produce the work, and there is none better fitted than Sir Lawrence to comprehend the minutiæ of the buildings and career of the greatest English architect.

Sir Lawrence Weaver's account of Wren is authentic. Although the scope of the little book precludes an exhaustive study of the personality of the architect, the author describes parentage and childhood, Wren's contemporaries, his gifts as a scientist, his travels in France. One illustration shows him as a man of forty: it is a picture both engaging and youthful looking, yet at this age the cares of his professional career must have been heavy. Another illustration is the "Welbeck Portrait," and yet another the Wadham portrait copied by John Smith of Oxford in 1825. Following are the portraits by Kneller and Elisha Kirkall, revealing the facial aspect of the architect at maturity. In addition, there are a series of excellent line drawings by E. H. New, mainly dealing with the towers of the City churches.

In this work the author has wisely followed the course of presenting a new view of the great architect's career in a series of sketches happily arranged which go far to bring into relief the talents and labours, no less than the successes, of an English gentleman.

That Wren towers above the society of his time is common knowledge; his personality broods over London, his spirit frequents the panelled rooms of Windsor and Hampton Court; one is conscious of his presence in the University cities; no cloaking, masking, nor donning of full-bottomed wigs can bring back the spirit of his age or the character of his works. Wren was not an actor, neither did he develop into a copyist; by natural endowment he was from first to last an inventor, and one gifted supremely with courage and audacity. Since his time building has advanced as a natural corollary to his labours; architects have traversed the gamut of classicality, they have resuscitated styles long since dead, they have sought for inspiration amidst the debris and rubbish heaps of craftsmanship long forgotten. These revivals and resuscitations have all been to the good, for there has resulted a clearer understanding of essentials relieved of the shibboleths and cant cries of prejudice and fashion. From the technical standpoint, let it be understood, the word practical is abhorrent; things have improved; planning is beginning to be fathomed—that is to say, planning unfettered by rigid observance of rules of style; rather the tendency to-day is directed to laws geometrical. Close study of tradition has at least altered the public viewpoint, especially in the region of domestic architecture. What is now required is that the young architect should, in addition to his appreciation of the subtle qualities and exactions of what may be termed historical building, acquire that detached and disinterested appreciation of form without which visionary ideas, however intriguing the latter may be, cannot be carried to a logical sequence. The moral to be gained from a study of the works of Sir Christopher Wren embraces thought altogether outside the scope of ordinary divisions. It is concerned essentially with imagination, with ideas; it has its centre, moreover, in the needs of the moment, for tradition is a bad master and welds fetters not easily thrown off. The study of a great artist, as of a coterie or of an historical period, proves that tradition in the past resulted from definite change with the sequence that preceded it. But such study does not prevent an assimilation of the supreme qualities which alone are indestructible and everlasting. A. E. RICHARDSON [*F.*].

Correspondence

THE PRESERVATION OF CARVINGS AND MOULDINGS IN ANCIENT BUILDINGS.

To the Editor, JOURNAL R.I.B.A.,—

Heriot-Watt College,
Edinburgh.

DEAR SIR,—In the lecture to Academy students last year on "Stone Preservation" I gave some account of the new stone preservative silicon ester, and it may interest your readers to know something of its method of application as derived from my own experience on decayed surfaces which represent the conditions to be found on priceless carvings and mouldings.

The special problem in which I am interested is the preservation of carvings and mouldings in ancient buildings. In many cases these mouldings, while preserving something of their original outward form, are so decayed and the stone is so rotten that the application of a brush means their destruction, and it is necessary to search for something which, while it can be applied as a thin and penetrating liquid, will as it dries act as a cement, rebinding the particles of the stone together. It is also evident that such a cement must of itself be practically indestructible. It was for these reasons that I finally adopted silicon ester for trial, as on exposure to moist air it deposits a cement of hydrated silica round the particles which is practically chemically indestructible.

The following is some account of how this liquid is to be used in practice.

It should be splashed or painted freely on with a soft flat brush, and as each application soaks in another application made.

It is impossible to lay down any rule as to the number of applications necessary, the stone absorbing from four to ten or fifteen coats according to its nature and condition of decay. The stone is not discoloured, but the final application when the stone is saturated dries with a slight gloss. This is not visible at a distance but for stone surfaces close to the eye it may be objected to and care must then be taken to make a sufficient number of applications to harden and bind the stone without going so far as to obtain a glossy surface. This is soon found by experience.

Often, in one moulding, one portion is badly decayed and very absorbent while another portion is only slightly absorbent, certain limestones for instance, decaying in this way and having a hard skin in places. The excess of liquid should be wiped off these portions with a sponge moistened with methylated spirits, or holding a sponge pressed to the stone below the especially rotten surface, repeated applications with a small brush can be made to the rotten surface itself.

Light coloured stones are not discoloured, but a limestone covered with the white flour of decay will necessarily look darker, and a dark coloured stone like a red sandstone will have a grey appearance if too much of the solution is applied; and it is necessary therefore in such cases to be very careful not to apply too much. In the case of such stones it is a good plan after the final application has soaked in, but before it has set, to wipe over the surface

with the sponge dipped in methylated spirits. Of course the dryer the stone the better the liquid is absorbed.

No brushing down should be done before application except in very special cases where, as in certain limestones, the whole surface is covered with a swollen and loosely adhering scaly surface which falls at the slightest touch. No preservative can penetrate this, and it may be lightly brushed off with a soft brush, but only by an expert who thoroughly understands the artistic value of the surface. No workman should be allowed to touch it.

After the surface has been saturated and hardened we have in many cases the problem of cracks and fissures, and portions which are deeply undercut by decay and ready to be detached. It is evident that if these conditions are left the mere hardening and re-cementing of the surface will be of little use.

I have therefore a suggestion to make which I put forward with all diffidence, as it may be objected to by some architects.

If some of the same stone is crushed to powder and mixed with a strong solution of the silicon ester, it can be used as a cement to fill up cracks and to pack in behind hanging and undercut portions. I have found this can be done, and the resulting surface being made of the stone itself may be trusted to weather to the same colour, though when first applied the freshly crushed stone may have a crude appearance. I leave this suggestion for the consideration of architects and others interested.

Fine old but decayed surfaces of brick work can be treated in the same way. After two or three applications over the whole surface, bricks which are in a very decayed condition can then be treated with repeated applications, a sponge being held against the brick below and a small brush being used. If the treatment is not carried too far the bricks are not altered in appearance. Over treatment will result in a grey appearance. Powdered brick and a strong solution can be used for filling up cracks.

After the bricks are hardened, it is possible to re-point but it must of course be very skilfully and carefully done.

No doubt this solution if it continues to prove its value as tested by time will have useful applications as a preservative agent on ordinary stone surfaces, and would be applied by spraying. The above instructions are intended for those who, having ancient buildings in their charge, should treat the carvings and mouldings with the minute and painstaking care which should be applied to the cleaning of a picture by Rembrandt.

I am, yours, etc.,

A. P. LAURIE.

HOUSING THE PEOPLE.

To the Editor, JOURNAL R.I.B.A.,—

DEAR SIR,—In *The Times* of 8 August appears an article, by its Rome correspondent, on Housing in Italy. It explains the Italian post-war system of obtaining small houses in quantity, which is summed up as follows :—

Success in Italy has been achieved by the grant of a substantial annual subsidy in the form of (*a*) remission of taxation ; (*b*) by the financing of building societies at a low rate of interest—2 to 3 per cent. ; (*c*) by a resolute policy, at whatever cost in popularity, of throwing the arrangement of the relationship between landlord and tenant upon the first parties themselves.

As compared with our own expensive complications and uncertainties this system appears to be a simple and common-sense one.

Our pre-war system of house building was one of private enterprise financed on easy terms, backed by the building societies with their loans for house purchase. It was our people's own way of getting their homes.

At the present time of uncertainty as to future building costs, the building societies cannot lend on mortgage to a purchaser a sufficient percentage of the purchase price, and as a consequence the builder must be content to leave a considerable sum sunk in each house he builds and sells as a second mortgage ; he cannot continue to do so indefinitely.

Under a system of Government guarantees the building societies would be prepared to lend almost the full purchase price, or an amount which together with the purchaser's available cash would pay for the house.

To subsidise builders with cash sums has the effect of raising the price of materials, but not of wages ; this has been proved quite recently, and it looks as though it were now in process of being proved again under the new Act.

There is, however, in this Act one hopeful sign. Section 5 (1) (b) empowers a local authority to guarantee to a building society the repayment of an advance made to any of its members desiring to build or acquire a house having an estimated value of not more than £1,500.

This clause looks something like the nucleus of a system of guaranteed house purchase which would not raise prices artificially, would not enforce the acceptance of ninepence for fourpence on people who prefer to be independent of such gifts, and which would begin to provide the required homes in adequate quantity. In fact, it is the only system which can be permanently successful.

The Italian system might be adapted to our own housing problem without difficulty, and I am convinced

with economy and with as much success as has been the case in Italy.

It is indeed certain that no efforts of Government can be successful unless based on the old and well tried method of house building that existed for so long in this country before 1914.

As to the part which qualified architects might play in such a scheme, it will be recognised that a new generation of house builders is getting to work, and that the Royal Institute of British Architects has already agreed with them upon a scale of fees to be charged by its members for this kind of work.—Yours faithfully, ARTHUR WELFORD [*A.*].

51 Years' Architectural Journalism

RETIREMENT OF MR. MAURICE B. ADAMS [*F.*].

Mr. Maurice B. Adams, who is retiring from his position of Architectural Editor of the *Building News* on the 20th inst., was elected an Associate in 1876 and a Fellow ten years later. He is a familiar personage at the Institute meetings, where he has so often contributed to the discussions. The *Building News* was founded in 1856, and is therefore, next to *The Builder* (founded in 1842), the oldest established existing architectural journal. Mr. Adams's long and honourable association with that paper, as well as his helpful activities in other directions and his works as an architect, were summarised in *The Times* of 15 September as follows :—

" Mr. Maurice B. Adams, F.R.I.B.A., the Architectural Editor of the *Building News*, is to retire at Michaelmas after fifty-one years' continuous service. No other architect has been engaged in the conduct of a professional journal for so long a time, the tenure of the editorship of *The Builder* for forty years by Mr. George Godwin, F.R.I.B.A., being the sole instance of a similar kind. The " Building News " Designing Club was personally conducted by Mr. Adams for thirty-seven years, and several of those who were members of it during that period have since become well-known architects either at home or in the Colonies.

" For a quarter of a century Mr. Adams was also hon. secretary of the Royal Architectural Museum and Art School in Tufton Street, and the scheme for presenting the museum and its remarkable collection to the Architectural Association was originated and carried through at his suggestion. The acquisition of this property by the Association subsequently enabled that society to secure its present quarters in Bedford Square when the museum trustees confirmed the transfer of the casts and examples to the Victoria and Albert Museum, South Kensington. Mr. Adams at one time served as one of the judges of the works submitted in the National Competitions for medals and prizes. He designed the Lord Leighton Memorial Art School and Polytechnic at Camberwell and a number of libraries and institutions for Mr. Passmore Edwards, including the School of Economics, which the latter presented to the University of London, and the design for which was selected in competition. Blickling Hall, Norfolk, was altered and restored by Mr. Adams for Constance Lady Lothian. He was, too, connected with Radford Park at its start in 1878, and built the School of Art, Memorial Chapel of All Souls, and the Parish Hall. He also completed the church.

" *Artists' Homes* and *Modern Cottages* are the titles of two of Mr. Maurice Adams's books. He was associated with Mr. R. Norman Shaw, R.A., and with Mr. E. W. Godwin, F.S.A., also with Colonel Edis [*F.*], in others."

Obituary

CHARLES STEWARD SMITH [*F.*].

Born in 1858, Mr. Charles Steward Smith was the eldest son of the late Mr. Charles Smith, J.P., F.R.I.B.A., a well-known Reading architect. He was educated at Reading School, and was subsequently articled to his father. On becoming qualified to practise he went to London, where he spent some years with different firms to gain professional experience. He then rejoined his father and was afterwards associated in business with him and Mr. Harry Hutt, A.R.I.B.A. On the death of his father he and Mr. Hutt continued in partnership. Mr. Smith became an Associate of the Royal Institute of British Architects in 1882, when he was awarded the " Ernest Turner " prize for sanitary science. In 1892 he was made a Fellow of the Institute. He was the first President of the Reading Society of Architects and was a member of the Council and first Vice-President of the Berks, Bucks and Oxon Architectural Association.

Amongst the many public buildings carried out whilst Mr. Smith was associated with the firm are extensions to the Royal Berkshire Hospital—including the new nurses' quarters, the contract for which has just been let—the Borough of Reading Isolation Hospital and Education Offices, the University College Buildings—including the gymnasium, the science and technical laboratories—and the Palmer Memorial Library, Wantage Hall, St. Patrick's Hall, St. Andrew's Hall, the Princess Mary Hostel of the G.F.S. in London Street, the Wilson Schools, Leighton Park School Swimming Baths, the Henley War Memorial Hospital, and the Science Laboratories, Bradfield College.

AUGUSTUS W. TANNER [*A.*].

We regret to record the death of Mr. Augustus W. Tanner, which occurred on 4 August last. Mr. Tanner, at the time of his decease, had reached the age of 80, and had only retired from active professional work two years ago. He was the oldest Associate on the R.I.B.A. register, having been elected in 1870, his serial number being 72. After serving his articles with Mr. Giles, of Craven Street, Strand, he entered the offices of the late George Edmund Street, R.A., and acted as one of his principal assistants during the erection of the Law Courts. He afterwards entered into partnership with Mr. Romaine-Walker, and, under the name of Romaine-Walker and Tanner, carried on private practice until 1896. In 1883 he was appointed District Surveyor for Hatcham, under the Metropolitan Board of Works, and in 1896 for Rotherhithe, part of Camberwell, Hatcham, and St. George's-in-the-East, under the L.C.C., when the acceptance of this office rendered it necessary for him

to dissolve partnership with Mr. Romaine-Walker. He was again re-appointed by the L.C.C. for the District of St. George's-in-the-East in 1907, and retained that position until his retirement in 1921. Having acted as District Surveyor for about 38 years, he naturally had a wide knowledge of the old Building Act and its many amendments. He had a keen sense of justice and, in his official capacity, held an equal balance between the letter and spirit of the law. A picturesque personality, quick to anger and equally quick to forgive, an indefatigable worker, and a really good fellow has gone to his well-earned rest.

R. STEPHEN AYLING [*F.*].

JAMES A. M. BAXTER [*A.*].

Mr. James A. M. Baxter [*A.*], Edinburgh, died on 21 August at the age of 43. He was Lecturer on Fire-Proof Construction and Plan-drawing at the Heriot-Watt College (the Technical School of Edinburgh) and chief assistant in the honours and advanced class of Building Construction in the same place, and was head draughtsman with Mr. F. W. Deas [*F.*], in whose office he had been for 24 years. Modest and unassuming, his grasp of practical building construction was equalled by his technical knowledge in almost every trade connected with it and by his admirable draughtsmanship. He was an enthusiast in his work with the enthusiast's enquiring mind and untiring energy. The testimonies of affection that have come from those who worked under him, or were in any way associated with him, show how deep and widespread his influence was.

F. W. DEAS [*F.*].

BOARD OF ARCHITECTURAL EDUCATION. EXHIBITION OF DESIGNS OF STUDENTS EXEMPTED FROM THE R.I.B.A. FINAL EXAMINATION.

The designs submitted by Students exempted from the Final Examination (with the exception of the subject of Professional Practice) are on exhibition up to Wednesday, 26 September 1923, inclusive, in the University of London Bartlett School of Architecture, Gower Street, by permission of the University College Committee. The exhibition will be open daily between the hours of 10 a.m. and 5 p.m., Saturdays 10 a.m. and 1 p.m.

The R.I.B.A. Board of Architectural Education Silver Medal for the Recognised Schools is awarded for the best set of designs submitted at this exhibition.

This year the following schools which have courses of five or more years' duration recognised by the Royal Institute for the purpose of exemption from the Final Examination have sent exhibits :—

The Architectural Association,
Liverpool University School of Architecture,
Glasgow School of Architecture,
Robert Gordon Technical College, Aberdeen.

The exhibition of designs submitted by Students exempted from the Intermediate Examination is being held by permission of the Council of the Architectural Association in the Studios of the Architectural Association, 34–36, Bedford Square, W.C.

ELECTION OF MEMBERS, 3 DECEMBER 1923.

Associates who are eligible and desirous of transferring to the Fellowship Class are reminded that if they wish to take advantage of the Election to take place on 3 December they should send the necessary nomination forms, etc., to the Secretary R.I.B.A., 9 Conduit Street, W.1, not later than 29 September 1923.

Examinations

R.I.B.A. PROBLEMS IN DESIGN.

SUBJECT LXXI.

(*b*) Working Drawings of Design Subject No. LXIX. (A School Library.)

Attention is drawn to the fact that, owing to a printer's error, the requirements for the drawings as set forth are incorrect.

The requirements should read as follows :—

" The design for a school library may, after it has been approved, be re-submitted with the addition of one ½ inch scale elevation and two ½ inch scale sections finished as working drawings. The section to show the bookcase fittings."

Competitions

TAUNTON SCHOOL WAR MEMORIAL.

The Council of the Taunton School invite designs for a War Memorial, consisting of an Art and Science Block, the cost of the building to be approximately £10,000, and they have appointed as Assessor Mr. Robert Atkinson, F.R.I.B.A., who will have the power to nominate a second Assessor if desirable. The premiums offered are one of £100 and a second of £50, the first premium to merge in the architect's commission.

Particulars, together with photograph of the present buildings, may be obtained from the Secretary of the School, Mr. H. J. Pollard, F.C.A., 3 Hammet Street, Taunton, in return for a cheque for £2 2s., which will be returned on receipt of a bona fide design.

SOUTHSEA COMMON LAY-OUT AND DEVELOPMENT COMPETITION.

Members and Licentiates of the Royal Institute of British Architects must not take part in the above competition, because the conditions are not in accordance with the published Regulations of the Royal Institute for Architectural Competitions.

IAN MACALISTER,
Secretary.

CHISWICK RIVER EMBANKMENT AND PROMENADE COMPETITION.

The Competitions Committee desire to call the attention of Members and Licentiates to the fact that the conditions of the above Competition are not in accordance with the Regulations of the R.I.B.A. The Competitions Committee are in negotiation with the promoters in the hope of securing an amendment. In the meantime Members and Licentiates are advised to take no part in the Competition.

COMPETITION FOR A NEW ASSEMBLY HALL AND EXTENSION OF EXISTING COUNCIL BUILDINGS, EASTLEIGH.

The Competitions Committee desire to call the attention of Members and Licentiates to the fact that the Conditions of the above Competition are not in accordance with the Regulations of the R.I.B.A. The Competitions Committee are in negotiation with the promoters in the hope of securing an amendment. In the meantime Members and Licentiates are advised to take no part in the Competition.

BOURNEMOUTH PAVILION COMPETITION.

The Assessor, Sir Edwin Cooper [*F.*] has now made his Award as follows :—

First : Mr. G. Wyville Home [*A.*], and Mr. Shirley Knight, A.R.I.B.A., of Lincoln Chambers, Portsmouth Street, Lincoln's Inn Fields.

Second : Mr. H. V. Ashley [*F.*], and Mr. Winton Newman, F.R.I.B.A., of 14, Gray's Inn Square, London, W.C.

Third : Messrs. Collcutt and Hamp and Mr. J. F. Watkins, Associated Architects, of 20, Red Lion Square, London, W.C.1.

SINGAPORE SOCIETY OF ARCHITECTS. ALLIED TO THE R.I.B.A.

The following letter has been received by the President from this newly allied Society to the Institute from Mr. S. Douglas Meadows, its President :—

"Dear Mr. President,—I am taking this opportunity of sending the greetings of the newly formed Singapore Society of Architects, which I fondly hope will become the youngest but nevertheless vigorous child of the mother body. There is a great work before us here and, given enthusiasm and proper organisation, the Society should do much to maintain the high standards of architectural work which have even now been established in the Colony. I hope ere long to be able to announce to the members here that the Institute has received this, her new offspring, under her protection."

Members' Column

MR. H. C. HUGHES.

Mr. H. C. Hughes, M.A. (Cantab.) (*A.*), while retaining his position as Librarian at the Cambridge University School of Architecture, has opened an office for his private work at No. 30, Sidney Street, Cambridge. Telephone : Cambridge 184.

T. BRAMMALL DANIEL & H. W. PARNACOTT.

The above partnership is being dissolved, by mutual consent of the partners, as from the 29th September 1923. On and after the 30th September next, Mr. T. Brammall Daniel will continue to practise at Members' Mansions, 36, Victoria Street, Westminster, S.W.1 ; the firm name being T. Brammall Daniel, F.R.I.B.A., Architect. (Telephone—Victoria 5797.)

NOTICE.

Widow of F.R.I.B.A. and a Tite Prizeman would be glad to share her house or let room to an Architect or would let the whole house in Bedford Park, furnished.—Apply Box 2023, c/o Secretary, R.I.B.A., 9, Conduit Street. W.

OFFICE TO LET.

Gray's Inn Square.—Well-lighted room ; part use of second room. Rent £72.—Apply Box 1293, c/o Secretary, R.I.B.A., 9 Conduit Street, W.1.

ROOMS TO LET.

Two good rooms in West Central district are being vacated by a Member. One free at Michaelmas and the other at Christmas. Rent £60 and £90 respectively, inclusive of heating, lighting, and service.—Apply Box 1993, c/o The Secretary, R.I.B.A., 9, Conduit Street, W.1.

PARTNERSHIPS WANTED.

Associate would be glad to meet another Member with a view to partnership in starting practice (W.C. district). One who is able to introduce part work preferred. Full particulars exchanged. Apply Box 1493, c/o Secretary R.I.B.A., 9 Conduit Street, London, W.1.

Architect and Surveyor, Licentiate, P.A.S.I., is desirous of entering into a Partnership or appointment view to same. Preferably South of England. All-round experience, and 15 years in practice.—Address W. A., c/o Barclays Bank, Osborne Road, Southsea.

CHANGES OF ADDRESS.

Professor Beresford Pite's offices and telephone number are now changed from The Royal College of Art, South Kensington, to 101 Great Russell Street, London, W.C.1. Telephone : Museum 2481.

After 30 September, Mr. W. R. Davidge's address will be 5 Victoria Street, Westminster. Telephone No. : Victoria 8454.

Mr. C. E. Hanscomb (*A.*) has changed his address to Station Approach, Sanderstead, Surrey. Telephone : Purley 1151.

APPOINTMENTS WANTED.

Architect, F.R.I.B.A., with 25 years' London practice in Architecture and wide varied experiences, seeks leading position in busy practice with view to future partnership, where his experience, practical and artistic qualifications, business connections and influence, also present architectural appointments and future works in view to be amalgamated and utilised to the fullest. Absolutely sound proposal to amalgamate and utilise energetic abilities. Box 3083, c/o Secretary, R.I.B.A., 9, Conduit Street, W.1.

Required by Licentiate, engagement in London district. Domestic work a speciality. Recently practising in town and could introduce work. Moderate salary. Would manage architectural department for an Estate Agent. Box 2883, c/o Secretary, R.I.B.A., 9 Conduit Street, London, W.1.

Architectural Assistant, crippled in War, desires professional work at home. Neat and correct draughtsman. Wide experience. References. Reply, Box 7923, c/o Secretary R.I.B.A. 9 Conduit Street, W.

Associate, 28, married, ex-Service, would like to hear from Architect abroad requiring assistance with his practice. Energetic, sound general knowledge, and could take entire charge of works. Some Colonial experience.—Apply Box No. 2,873, c/o Secretary R.I.B.A., 9, Conduit Street, London, W.1.

Associate (38) wishes Appointment. Thoroughly capable and experienced all-round man (twenty years London and Far East). Ex-officer. Now disengaged. Would be pleased to assist Architects temporarily.—Apply Box 1893, c/o The Secretary, R.I.B.A., 9, Conduit Street, London, W.1.

ASSISTANT WANTED.

Wanted Immediately, a thoroughly competent Assistant (London trained preferred), for a period of six to twelve months, for Elementary and Secondary School designs and details. None but first-class men should apply. Salary at the rate of £450 to £500 per annum according to ability. Applications to be sent in not later than Saturday, 29th September, 1923.—W. Vincent Morgan, A.R.I.B.A., County Architect, Carmarthen.

LONDON ADDRESS REQUIRED.

Architect, with practice in Surrey, requires London address. Assistance or mutual arrangement if required, or would take over practice.—Box 4923, c/o The Secretary R.I.B.A., 9, Conduit Street, London, W.1.

MR. GERALD R. CLAYTON.

Mr. Gerald R. Clayton, A.R.I.B.A., recently commenced practice at 5, Higher Church Street, Blackburn, and will be pleased to receive trade catalogues.

R.I.B.A. JOURNAL.

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